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ABSTRACT

Developed by the Department of Agricultural Education of the Pennsylvania State University and field-tested by 54 teachers, this guide is for teacher use in planning a unit in greenhouse crop production. The unit is intended for upper high school and post-high school students interested in careers in this field. Teacher suggestions, references, and information from the Student's Handbook (VT 010 880), which includes learning objectives, key questions, vocabulary terms, and subject matter, are provided for these problem areas: (1) Occupational Opportunities in Greenhouse Crop Production, (2) Greenhouse Location, Structures, and Equipment, (3) Environmental Control, Potted Plant Production, (4) Cut Flower Production, and (5) Vegetable Production. A Cumulative Table of Days per Year, Flower Holidays for 1970-1976, and a greenhouse crop production examination are appended. (SB)

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Greenhouse Crop Production

A Teacher's Manual

(Courtesy, George J. Ball, Inc., West Chicago, Ill.)

The Pennsylvania State University
College of Agriculture
Agricultural Experiment Station
Department of Agricultural Education
University Park, Pennsylvania

Teacher Education Series
Volume 10 Number 3t
1969

VT010879

This publication was prepared and edited by the following staff members of the Department of Agricultural Education, College of Agriculture, The Pennsylvania State University: Jesse S. Clemmons, Celedonio M. Gapasin, and Douglas Hitchcock, Graduate Assistants; William J. Brown, Jr., and J. Robert Mercer, Instructors; and Gene M. Love and Richard F. Stinson, Associate Professors.

Technical assistance was received from John W. Mastalerz and John W. White, the Department of Horticulture, College of Agriculture, The Pennsylvania State University and Darrell E. Walker, Professor and Head of the Department of Horticulture.

Illustrations, photographs, and an accompanying series of color slides were largely the work of Christopher Shelly, Graduate Assistant, and Richard W. Tenney, Instructor, Department of Agricultural Education.

Where trade names are used, no discrimination is intended, and no endorsement is implied.

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ED038538

Introductory Statement

Greenhouse Crop Production--A Teacher's Manual, is one of a series of instructional aids being prepared and edited by the Department of Agricultural Education through a contractual agreement between The Pennsylvania State University and the United States Office of Education, Division of Adult and Vocational Research. In addition to the development of instructional aids, the contract provided for two teachers' institutes in ornamental horticulture. The institutes were held July 5-22, 1966, and July 3-21, 1967.

The fifty-four teachers from the northeastern states who participated in the teachers' institutes were asked to evaluate and help improve the organization and the content of this instructional aid. They field-tested the unit with classes in their schools.

A special advisory committee has provided guidance in the selection of areas of emphasis for this unit of instruction. The committee has assisted by outlining key problem areas and by suggesting important subject matter information to be included. In addition to John W. Mastalerz, John W. White, and Darrell E. Walker, who have been cited previously, the following persons have served in an advisory capacity for the development of this unit of instruction: Peter B. Pfahl, Associate Professor of Floriculture, The Pennsylvania State University; Charles C. Drawbaugh, Assistant Professor, Agricultural Education, Rutgers, The State University; William H. Annis, Assistant Professor and Head, Department of Agricultural Education, University of New Hampshire; and John H. Walker, Executive Director, Society of American Florists and Ornamental Horticulturalists.

Richard F. Stinson, Project Director
David R. McClay, Associate Project Director
Glenn Z. Stevens, Associate Project Director

NOTE

Federal legislation now forbids the use of certain pesticide materials recommended in this publication. Consult current recommendations before using insecticides, fungicides, and herbicides.

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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Teaching the Unit

Greenhouse Crop Production was written for upper high school and post-high school students interested in entering careers in this business. It can be used either for students exploring careers in greenhouse crop production or for students developing or improving their skills in this career.

Greenhouse crop production is an important nonfarm agricultural business in the Northeastern United States. Before teaching this unit, it would be useful to determine the greenhouse employment possibilities in the area served by the school as well as the county in which the school is located. Interviewing greenhouse managers will familiarize teachers with the requirements for employment and job opportunities, as well as provide business contacts that are valuable in carrying out work experience programs.

This unit was written primarily from the standpoint of the culture of the crops. Other related units that would be valuable to the students are horticultural mechanics as well as flower shop operation and management. Exposure to elementary plant physiology, plant science, soils and fertilizer, and elements of human relations are highly recommended.

Supervised occupational experience programs should be included as an integral part of the instructional unit. Placement experiences will offer students an opportunity to learn by doing. It will also help them develop good work attitudes. Students should be placed in greenhouse businesses from which they will gain the most experience in the particular areas of emphases included in this unit. Successful occupational work experience programs are developed only if sufficient time is scheduled for on-the-job supervision of these students by a teacher. Before the school year begins, arrangements should be made for placing students. A definite understanding among the employer, the student, his parents, and the teacher, in regard to hours, wages, responsibilities, duties and skills is a key to successful work experience programs. The teacher, student, and employer together should develop a check-off list of experiences the student is to have. These should be reviewed frequently during the occupational experience programs.

The school greenhouse should be operated as a laboratory that simulates commercial production. Crops should be scheduled for major holidays and must be of commercially competitive quality. Potted plants should be assigned to student care on the basis of at least fifty plants per student; cut flowers, 100 square feet per student. Until he can satisfactorily produce a crop in the school greenhouse, a student is not prepared for work experience placement. Advanced students should be provided challenging crops such as potted roses, African violets, or "growing-on" azaleas and hydrangeas.

This Teacher's Manual consists of the Student Handbook plus suggestions to the teacher. Suggestions to the teacher have been included on green sheets at the end of each problem area. In planning to teach a problem area the teacher may wish to proceed as follows:

1. Read the student material.
2. Obtain some or all of the references recommended.
3. Select and order visual-aids and supplies.
4. Read the suggested student learning activities.
5. Read the key questions to be emphasized before teaching the unit.

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PROBLEM AREA 1

OCCUPATIONAL OPPORTUNITIES IN GREENHOUSE PRODUCTION

Learning Objectives

1. To learn about the kinds of occupations in commercial greenhouse crop production and the duties and responsibilities of each.
2. To find out the kind of education and the experience needed for each of these occupations.

Key Questions

1. What are the job opportunities in commercial greenhouse crop production?
2. What are the skills needed by the people engaged in these jobs?
3. How can you learn these skills?
4. Which jobs interest you?

New Words

Attributes - a quality that belongs to a person

Coordinate - to get something to work or mesh together

Grade - one of several size groups

Interpret - to say in another way

Operation - a method of doing a task

Peculiar - applying to only one thing

Personnel - employees

Quality - degree of perfection

Rotation - a succession of crops

Technique - a particular way of doing a task that requires detailed knowledge

Greenhouse Manager

The greenhouse manager may also be the owner of the business he manages. The following managers are directly responsible to him: production manager, physical plant manager, and sales manager. In a small business he may have the responsibilities of all these positions himself. Frequently the greenhouse manager and the production manager divide these responsibilities between them.

The greenhouse manager is responsible for the overall operation of the company. He assigns the duties and responsibilities to the other managers, and assists them in solving problems related to their areas. He also coordinates the work of the departments so that the company can achieve its production and marketing goals. He must be skilled in getting his "team" to work together smoothly.

He must be thoroughly familiar with crop production techniques, business principles, and personnel management. A B.S. degree in horticulture would be highly desirable, although graduates of a strong post-high school vocational program might qualify. In either case from 3 to 5 years of practical experience would also be required.

Production Manager

The production manager's job is to plan and supervise the growing of the kinds of cut flowers and potted plants which the management has decided to produce and sell. He must plan crop rotations, order plants, seeds, and supplies, and program the work to be done. He should not only have detailed knowledge of the latest cultural techniques for the crops being grown so that he can produce the grade and quality that the market demands, but he must also supervise the grading, packing, and shipping of the products. In addition, he must be able to get along well with people.

The production manager is directly responsible to the greenhouse manager. The technician and the foremen are directly responsible to him.

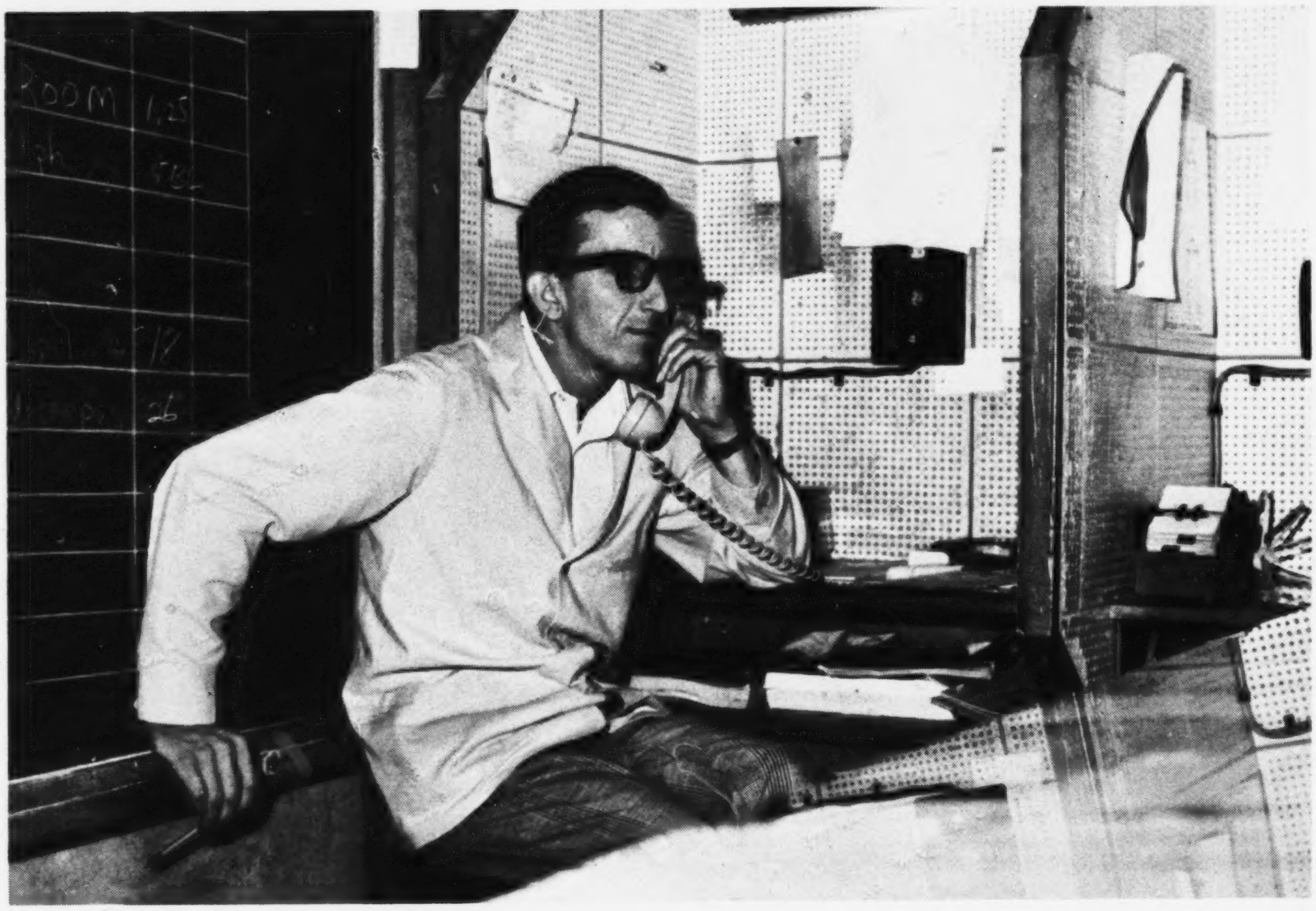
Many persons holding this position have a B.S. degree in horticulture. Possibly there are more with a post-high school vocational education in horticulture. In any case, a number of years of practical experience would be needed to qualify for this position.

Physical Plant Manager

The physical plant manager supervises the heating plant personnel and the maintenance crews, plans work schedules, orders materials, and keeps records of regularly scheduled jobs. He needs a thorough background in mechanical and agricultural engineering as well as a practical knowledge of the structures and equipment peculiar to the greenhouse business. A knowledge of greenhouse crop production methods would be very useful but not essential.

He is directly responsible to the greenhouse manager. Persons directly responsible to him include the firemen, night watchmen, and the maintenance crew foremen.

The physical plant manager is usually a graduate of a post-high school vocational program in engineering. He is not fully qualified for the position until after several years of experience in greenhouse maintenance work.



Sales Manager

The sales manager coordinates the work of the sales staff, advertises the products, prices the products, and supervises the shipment of them. He works closely with the greenhouse manager and the production manager in planning the kinds, quality, and timing of crops to be grown. His sales records are an essential guide in this planning. His main job is to find prospective customers as well as maintaining contact with established customers. He supervises the billing and frequently serves as the financial officer of the company.

The sales manager is directly responsible to the greenhouse manager. He usually supervises the work of one or more clerks and typists.

The sales manager may hold a B.S. degree in agricultural business or business administration, although post-high school training at a business school is the educational background of many. Prior experience in greenhouse production or at a wholesale flower market would be highly desirable but not essential.

Technician

A greenhouse technician is a "trouble shooter" for the crop production phase of the business. He must be able to test soil, interpret the results, and make fertilizer recommendations. He must be able to recognize insect and disease problems and know the latest control methods for them. The technician must know how to use growth regulating chemicals. He might be called upon to straighten out an unsatisfactory rotation schedule, or figure out why a crop was too early or too late. A technician might be asked to devise ways of shortening or eliminating certain costly operations.

He is responsible to the production manager-- a kind of "right hand man."

A greenhouse technician sometimes holds a M.S. degree, or more frequently a B.S. degree in horticulture. Some junior college graduates might qualify for this position. Regardless of formal education, several years of practical experience in greenhouse production would be required, and an eagerness to continue learning would be essential for a person in this position.

Foreman

The foreman oversees a section of a greenhouse range. In a large range he might be responsible for a single crop such as roses, carnations, or orchids. He schedules crop rotations, takes inventories, orders supplies, and supervises and trains growers. He helps growers plan their work schedules and assists them in solving production and personnel problems.

The foreman is directly responsible to the greenhouse manager. He supervises the work of from 2 to about 6 growers.

A greenhouse foreman might hold a B.S. degree in horticulture, but a greater number are graduates of a two-year, post-high school program in horticulture. They must not only be well informed about cultural techniques for the crops in their charge but must be skilled in personnel relations. Several years of greenhouse experience in greenhouse production are required in addition to the educational qualifications.

Grower

A grower is responsible for carrying out the physical work involved in growing a greenhouse crop. He is usually responsible for a single greenhouse of a cut flower crop, or several small greenhouses of potted plant crops. The grower does the soil preparation, planting, fertilizing, watering, pruning, and pinching. He also applies pest control materials and may apply growth regulating chemicals. The grower also harvests the cut flowers and potted plants and moves them to the grading and shipping areas of the range.

A grower is directly responsible to the greenhouse foreman. From one to several workers may be assigned to help him with his work. He must be able to work well with a group of people.

Growers are often graduates of a 2-year post-high school program in horticulture, although many are high school graduates with an interest in greenhouse production. In either case, a year or two of greenhouse experience is a necessary qualification.

FUTURE FARMERS OF AMERICA

Grower Assistant

A greenhouse grower assistant assists the grower in performing his tasks. In addition to the jobs directly involved in growing the plants, he may work at maintenance and repair of facilities and equipment during off-crop periods in the summer months. In large operations some assistants may be involved only in the grading, packing, and shipping operation. Some workers are employed on a seasonal basis to help during periods of heavy work loads with certain crops, such as bedding plants, (flower and vegetable transplants), during March, April, and May.

Most grower assistants are high school graduates, but a high school diploma is not essential. A worker who is productive, willing to learn, accepts responsibility, and gets along well with his fellow workers may expect increased responsibilities and wages during the first year of employment. An interest in plants, mechanics, and people are attributes of a successful employee in a greenhouse firm.

EMPLOYMENT REQUIREMENTS

Written requirements for employment in a commercial greenhouse range are unobtainable because most persons interested in this work are interviewed orally.

The Civil Service Commission of large cities sometimes publishes requirements for greenhouse employees. The following examples for the cities of Detroit and Pittsburgh indicate the requirements, including a written examination. These requirements may be similar enough to those for commercial employment and should be helpful to you in discussion with your students.

Civil Service Examination Announcement

FLORICULTURIST (MALE)

EXAMINATION DATE: Continuing until further notice but not to exceed July 31, 1969

FILING PERIOD: Continuing until further notice but not to exceed June 28, 1969

VACANCIES: Some

SALARY: $3.75 to $3.86 per hour

NOTE: Applications will be accepted from persons who will attain the minimum age limit within 90 days of the examination date, but such persons will not be appointed until they attain the minimum age.

THE ENTIRE ANNOUNCEMENT SHOULD BE READ CAREFULLY BY APPLICANT

GENERAL REQUIREMENTS: Applications must be made on an official blank which may be obtained at the offices of this Commission, 6th floor, City-County Building, 2 Woodward Avenue, Detroit, Michigan, 48226. All applicants must be of good health, habits and moral character.

Minimum entrance qualifications in the specification are to be interpreted as the requirements of successful applicants and not as restricting the right of any person to be examined who otherwise meets the requirements as set forth herein.

All examinations will be public, free and competitive to all citizens of the United States who conform to the specific limitations as provided. Applicants will be admitted to the written test only upon presentation of the official notice obtained through acceptance of application.

In addition to the written test, this examination will include an evaluation of experience and training based on investigation and/or personal interview. Recency of experience may be considered in the evaluation. Medical and/or physical examinations may be required of all candidates who are successful in the other subjects of the examination.

ELIGIBLE LIST: All passing applicants will be placed on an eligible list. If there is an existing list, the names of all qualified candidates will be placed on a consolidated list in the relative position of their examination scores.

RESIDENCE REQUIREMENTS: Applications will be accepted from non-residents but upon certification a bona fide residence must be established in the City of Detroit. Where resident eligibles are available, they will be certified before non-residents.

	SUBJECTS AND WEIGHTS OF EXAMINATION	Maximum	Required Minimum
1.	Written Examination	50%	32.5%
2.	Practical or academic education and training	30%	19.5%
3.	Character, reputation, veracity, physical condition, etc.	10%	6.5%
4.	TOTAL	90%	70%
5.	Experience in this or similar work	10%	--
6.	TOTAL	100%	70%
7.*	Military Service	(1 to 15%)	

APPLICANTS MUST ATTAIN REQUIRED MINIMUM PERCENTAGE ON WRITTEN PORTION OF EXAMINATION BEFORE BEING RATED ON OTHER PARTS OF EXAMINATION.

* Persons rated as Detroit Veterans are entitled to the following benefits based on service in the Armed Forces of the United States during time of war: additional points added to their passing score.

(V) Dated: July 1, 1968

City of Detroit - Civil Service Commission
6th floor, City-County Building, 2 Woodward Avenue

(over)

DETROIT CIVIL SERVICE COMMISSION

Code: 51-20-31

Class Title: FLORICULTURIST

DUTIES STATEMENT: Under general supervision, to perform a variety of tasks in connection with the propagation, cultivation, care, and exhibition of native and tropical plants in greenhouses, buildings and park areas; and to perfrom related work as required.

TYPICAL EXAMPLES OF WORK PERFORMED: Subject to general and specific assignments, consultations with superiors and inspection of work, but with responsibility for using proper work methods:

Performing the individual tasks involved in: planting seeds; layering, making cuttings and grafts; setting out plants, bulbs, and tubers; potting and repotting plants; cultivating, fertilizing, and watering plants; pruning shrubs and vines; preparing and applying insecticides and fungicides; collecting seeds, regulating the temperature of greenhouses and conservatories; laying out and planting flower beds; carrying out plans for arranging flowers for show; as required, supervising the work of a small group of helpers in preparing soil, watering, fertilizing, and cultivating plants, setting out bulbs and tubers, storing bulbs and tubers, potting plants, and covering perennials for the winter; by assigning tasks, instructing the workers and inspecting the work in progress and upon completion; repairing small tools and equipment used in cultivating flowers and plants.

MINIMUM ENTRANCE QUALIFICATIONS: Education equivalent to graduation from an accredited high school and preferably completion of two years in a university of recognized standing with courses leading to specialization in horticulture, floriculture or other related field; reasonable experience in garden and greenhouse work; reasonable knowledge of propagation and cultivation of native and tropical plants; reasonable familiarity with greenhouse methods of propagation and cultivation of plants; reasonable knowledge of methods used in protecting plants from diseases and insect pests; skill in planting and making cuttings; mechanical aptitude; physically active; good powers of observation; industry and dependability; physically and mentally capable of performing all the duties of the classification.

AGE LIMITS: Minimum - 24 years.

NOTE: Employees in this class will be required, when necessary, to operate a motor vehicle.

Title Changed: 8-17-53
Spec. Revised: 5-26-67

Civil Service Examination Announcement

FLORICULTURE ASSISTANT

EXAMINATION DATE: Continuing until further notice but not to exceed July 31, 1969

FILING PERIOD: Continuing until further notice but not to exceed June 28, 1969

VACANCIES: Some

SALARY: $3.22 to $3.275 per hour

NOTE: Applications will be accepted from persons who will attain the minimum age limit within 90 days of the examination date, but such persons will not be appointed until they attain the minimum age.

THE ENTIRE ANNOUNCEMENT SHOULD BE READ CAREFULLY BY APPLICANT

GENERAL REQUIREMENTS: Applications must be made on an official blank which may be obtained at the offices of this Commission, 6th floor, City-County Building, 2 Woodward Avenue, Detroit, Michigan, 48226. All applicants must be of good health, habits and moral character.

Minimum entrance qualifications in the specification are to be interpreted as the requirements of successful applicants and not as restricting the right of any person to be examined who otherwise meets the requirements as set forth herein.

All examinations will be public, free and competitive to all citizens of the United States who conform to the specific limitations as provided. Applicants will be admitted to the written test only upon presentation of the official notice obtained through acceptance of application.

In addition to the written test, this examination will include an evaluation of experience and training based on investigation and/or personal interview. Recency of experience may be considered in the evaluation. Medical and/or physical examinations may be required of all candidates who are successful in the other subjects of the examination.

ELIGIBLE LIST: All passing applicants will be placed on an eligible list. If there is an existing list, the names of all qualified candidates will be placed on a consolidated list in the relative position of their examination scores.

RESIDENCE REQUIREMENTS: Applications will be accepted from non-residents but upon certification a bona fide residence must be established in the City of Detroit. Where resident eligibles are available, they will be certified before non-residents.

	SUBJECTS AND WEIGHTS OF EXAMINATION	Maximum	Required Minimum
1.	Written Examination	70%	45.5%
2.	Physical and Personal Qualifications	15%	9.75%
3.	Education and Training	15%	9.75%
4.	TOTAL	100%	70%
5.*	Military Service (1 to 15%)		

APPLICANTS MUST ATTAIN REQUIRED MINIMUM PERCENTAGE ON WRITTEN PORTION OF EXAMINATION BEFORE BEING RATED ON OTHER PARTS OF EXAMINATION.

* Persons rated as Detroit Veterans are entitled to the following benefits based on service in the Armed Forces of the United States during time of war: (1) additional points added to their passing score, (2) age waiver equal to time spent in military service during time of war.

(V) Dated: July 1, 1968

City of Detroit - Civil Service Commission
6th floor, City-County Building, 2 Woodward Avenue

(over)

DETROIT CIVIL SERVICE COMMISSION

Code: 51-20-21

Class Title: FLORICULTURE ASSISTANT

DUTIES STATEMENT: Under supervision, to perform routine and moderately difficult tasks in the propagation, planting and care of native and tropical plants in greenhouses, buildings and park areas; to assist with the more technical phases of floriculture work; and to perform related work as required.

TYPICAL EXAMPLES OF WORK PERFORMED: In accordance with specific work assignments, with specific instructions as to work to be done and with close supervision over both methods and results, but with some latitude for exercising independent judgment in carrying out the details of the work, performing the more routine tasks and assisting a florist in the more technical work involved in:

Preparing soil; planting seeds; making cuttings; layering; setting out plants, bulbs and tubers; potting and repotting plants; watering, fertilizing, and cultivating plants; pruning shrubs and vines; spraying and dusting plants for protection against insect pests or as treatment for plant diseases; preparing flower exhibits for show; storing bulbs and tubers; collecting seeds; regulating the temperature in greenhouses and conservatories; covering perennials for winter protection; as required, cutting grass and repairing small tools and equipment used in cultivation; using small, low-powered motorized equipment such as tillers, soil shredders, and sprayers.

MINIMUM ENTRANCE QUALIFICATIONS: Education equivalent to graduation from an accredited high school and preferably completion of two years in a university of recognized standing with courses leading to specialization in horticulture, floriculture or other related field; some experience in garden and greenhouse work; familiarity with greenhouse methods of propagation and cultivation of native and tropical plants; some knowledge of methods used in protecting plants from disease and insect pests; some skill in planting and making cuttings; mechanical aptitude; physically active; industry and willingness to learn and to perform any assigned tasks; physically and mentally capable of performing all the duties of the classification.

NOTE: Employees in this class will be required, when necessary, to operate a motor vehicle.

AGE LIMITS: 20 - 30
20 - 35 (Temporary maximum age limit)

Title Changed: 8-17-53
Spec. Revised: 5-26-67
Temporary Change in Age Limits: 12-19-67

City of Pittsburgh
Pennsylvania

CIVIL SERVICE COMMISSION

SUITE 526
CITY-COUNTY BUILDING
PITTSBURGH 19, PA.

POSTED:
9/16/68

THE CIVIL SERVICE COMMISSION ANNOUNCES A COMPETITIVE EXAMANATION FOR:

FLORIST

SALARY: Grade 10 $6261.00 ~~$5163.00~~ - $6571.00 per year

DEPARTMENT: Parks and Recreation
DIVISION: Conservatories & Gardens

DATE: 9:30 A.M., Monday, September 30, 1968 at 526 City-County Bldg., Pittsburgh, Pa.

Any person interested in this examination who meets the qualifications listed below may obtain the required application in Room 526 City-County Building between the hours of 8:30 A.M. to 4:30 P.M., weekdays, and 8:30 A.M. to 12:00 Noon, Saturdays.

ALL APPLICATIONS MUST BE FILED ON OR BEFORE 4:00 P.M., WEDNESDAY, SEPTEMBER 25, 1968

DUTIES: Propagation, production and care of greenhouse and outdoor ornamental plant materials used for exhibition and education purposes, performance of duties to include responsibility of plants and accessories in greenhouses, portion of the conservatories cold frames and hot beds or garden areas assigned to the individual.

QUALIFICATIONS:

AGE: 21 years, minimum

EXPERIENCE: At least three (3) years experience in the growing and maintenance of plant materials in greenhouses.

NOTE: This experience must be verified by satisfactory written evidence submitted with application.

KNOWLEDGE AND ABILITIES:

Applicant must have a good working knowledge of ornamental plant materials both for indoor and outdoor uses, to include the propagation, handling and care of these materials. Must know and understand water requirements, temperature controls and the control of pests of plants grown under glass.

EXAMINATION: Written examination valued at 100%

PHYSICAL EXAMINATION: Required at time of appointment.

VETERAN'S PREFERENCE:

Will be awarded to qualified veterans who score a passing grade on the written examination. To qualify, you must have an Honorable Discharge from active duty with the Armed Forces of the United States. Dates for creditable service are December 7, 1941 thru July 27, 1953 and July 1, 1958 to date.

CIVIL SERVICE COMMISSION

CD Martrano

C. D. Martrano
Secretary & Chief Examiner

ALL APPLICANTS MUST BE CITIZENS OF THE U.S., AND MUST HAVE RESIDED IN THE CITY OF PITTSBURGH AT LEAST TWO YEARS PRIOR TO FILING APPLICATION.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

References:

An Introduction to Agricultural Business and Industry. Ref. No. 1.

A One-Year Greenhouse Laboratory Course of Study for Vocational Agriculture in Pennsylvania. Ref. No. 2.

Careers in Ornamental Horticulture, 405 Centennial Building, Springfield, Illinois 62706.

Careers in Agribusiness and Industry, The Interstate Printers and Publishers, Inc., Danville, Illinois.

Handbook of Agricultural Occupations.

Dictionary of Occupational Titles. Third Edition, Volumes I and II. United States Department of Labor, Bureau of Employment Security, 1965.

Exploring Occupational Opportunities in Ornamental Horticulture, The Center for Research in Leadership and Development in Vocational and Technical Education, The Ohio State University, Columbus, Ohio, 1965.

Supervised Occupational Experience in Agriculture, Plans and Records. The French-Bray Prtg. Co., Candler Bldg., Baltimore, Md. 21202. Fourth Edit. 1969. 3 copies per $1.00

Teacher's Guide, Supervised Occupational Experience in Agriculture, Plans and Records. Rev. Edit. 1969. The French-Bray Prtg. Co., Candler Bldg., Baltimore, Md. 21202. 60¢ per copy.

The Teacher - Coordinator's Manual for Directed Work-Experience Programs in Agriculture. Cornell Misc. Bal. 91, Cushman, H.R., C.W. Hill and J.K. Miller. N.Y. State Coll. of Ag., Cornell Univ., Ithica, N.Y. June 1968. 50¢

Supplies Needed:

None

Audio-Visual Aids:

None

Suggested Learning Activities

1. Arrange a field trip to a greenhouse to introduce students to the occupations in greenhouse crop production.
2. Have the class participate in a survey of occupational opportunities in the retail flower business which exist in the local community.

3. Interview persons employed in greenhouse crop production to help to inform students of career requirements.
4. Have each student become familiar with the use of the Dictionary of Occupational Titles, Volumes I and II.

Test

1. What educational qualifications are desirable to become a successful greenhouse manager?
2. What are the specific duties of the production manager?
3. To which manager is the technician responsible?
4. What are the responsibilities of the foreman?
5. What is the title of the person responsible for the physical work involved in growing a greenhouse crop?

PROBLEM AREA 2

GREENHOUSE LOCATION, STRUCTURES AND EQUIPMENT

Learning Objectives

1. To find out why greenhouses have been built in certain locations.
2. To learn the parts of a greenhouse structure.
3. To learn the importance of atmospheric control and the methods used to maintain the correct temperature, relative humidity, and carbon dioxide levels in a greenhouse.
4. To learn about special equipment used in greenhouse production.
5. To learn the importance of light intensity and duration as related to growing of greenhouse crops.

Key Questions

1. How close to its markets should a potted plant range be located?
2. What are the parts of a greenhouse?
3. What are the kinds of greenhouses?
4. What glazing materials are used?
5. How are benches constructed and arranged?
6. What systems of heating and cooling are commonly used?
7. What is the value of CO_2 to plants in a greenhouse?
8. Why is it necessary to keep the air circulating in a greenhouse?

New Words

Boiler - a piece of equipment for boiling or heating water

Condensate - water droplets formed from moisture in the air

Cyclic lighting - short interruptions during the dark period

Diffuse - complete mixing of two gases or liquids

Foot candles - the amount of light given by a standard candle at a distance of one foot

Framework - the basic or principal part of something

Glazing - a hard, smooth, or shiny substance or coating used to cover a surface

Light intensity - the strength of light

Mist - water in the form of small particles floating or falling in the air

Photoperiod - length of day

Range - a group of greenhouses under one operation

Relative humidity - the amount or degree of moisture in the air

Respiration - the process by which a living organism or cell takes in oxygen and gives off carbon dioxide

Shade - reduced light intensity

Soil structure - is the clumping arrangement of individual soil particles

Structures - buildings

Subirrigation - adding water from below the soil surface

Syringing - to lightly moisten something -- usually plants

Texture - refers to the size of soil particles, such as sand, silt, and clay

Thermostat - a device for automatically regulating temperature

Toxic - a chemical substance that is harmful to a plant or animal

Transite - a mixture of asbestos with concrete in thin sheets

Ventilation - process of circulating fresh air

Purpose of Greenhouse Structures

Greenhouse structures make it possible to grow flower and vegetable crops the year around by providing an enclosed space in which the temperature can be controlled and plants are exposed to sunlight. Most plants grow best within a fairly narrow temperature range. Certain plants may not produce flowers if temperatures are too low in winter or too high in summer. Within limits, greenhouses equipped with automatic heating and cooling devices can come close to satisfactory year-around climatic control for plants. Sunlight intensities are often too low in winter for best plant growth in greenhouses. This can be partially compensated for by artificially increasing the carbon dioxide of the air within this enclosed space (greenhouse) causing the plants to manufacture food more efficiently.

Location of Greenhouse Ranges

Before discussing the location of greenhouse ranges, it is important to state that the purpose of a greenhouse is to produce flowers and vegetables at seasons when these products are otherwise not readily available in a particular marketing area.

Ranges that produce potted flowering plants, foliage plants, and bedding plants are generally located within 50 to 100 miles of their major markets. These crops cannot be shipped long distances because the cost of shipping their weight becomes uneconomical beyond a certain distance. Figure 1 shows the markets served with potted plants by a large Eastern United States greenhouse crop production firm.

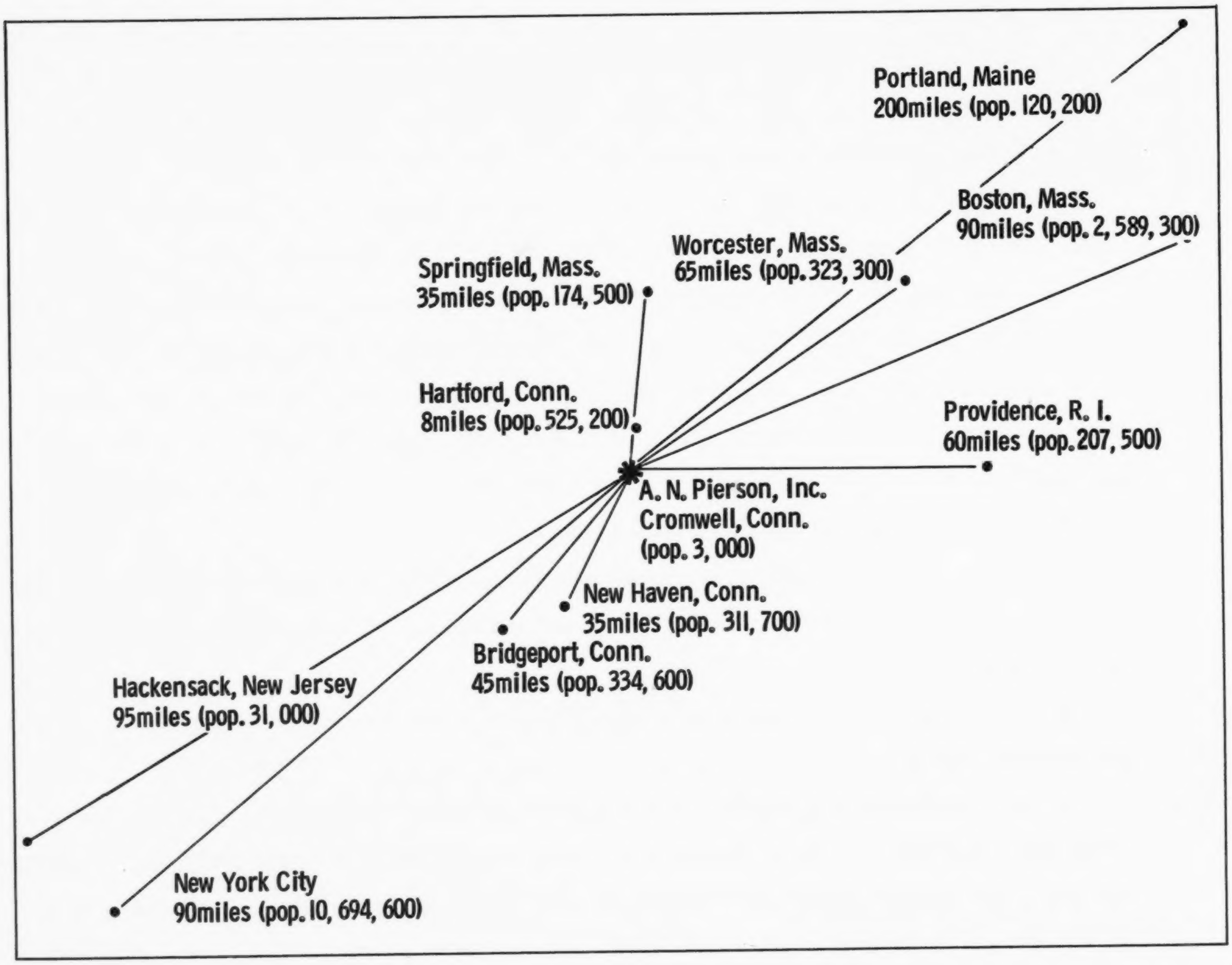

Portland, Maine
200miles (pop. 120, 200)
Boston, Mass.
90miles (pop. 2, 589, 300)
Worcester, Mass.
65miles (pop. 323, 300)
Springfield, Mass.
35miles (pop. 174, 500)
Hartford, Conn.
8miles (pop. 525, 200)
Providence, R. I.
60miles (pop. 207, 500)
A. N. Pierson, Inc.
Cromwell, Conn.
(pop. 3, 000)
New Haven, Conn.
35miles (pop. 311, 700)
Bridgeport, Conn.
45miles (pop. 334, 600)
Hackensack, New Jersey
95miles (pop. 31, 000)
New York City
90miles (pop. 10, 694, 600)

Figure 1 . Marketing area for potted plants for A. N. Pierson, Inc., Cromwell, Connecticut.

Greenhouse vegetable crops, such as tomatoes and lettuce are generally marketed within several hundred miles of the greenhouse ranges producing them. Again, the factor limiting long distance shipping is the weight of the product.

Cut flowers, because of their light weight, may be shipped long distances. A few, such as snapdragons and standard (football) chrysanthemums, do not ship well and are usually marketed within 50 to 100 miles of where they are produced. Certain high-value cut flowers may be shipped very long distances. For example, cymbidium orchids are shipped halfway around the world from Australia to Boston, New York, Philadelphia, and even to London and Paris. Hawaiian anthuriums and vanda orchids are shipped about 4,000 miles to Eastern U. S. flower markets. Within the continental United States, roses and carnations are shipped from California and Colorado to the Eastern U. S. markets, a distance of about 2,000 miles. Florida-grown gladioli and pompon chrysanthemums are marketed all over the United States.

In addition to a favorable marketing location, a greenhouse range must have adequate transportation facilities such as highways and airports.

The amount of winter sunlight is also important to greenhouses. Within a distance of only 20 miles there may be a marked difference in the number of sunny winter days. High hills and mountains tend to break up clouds, resulting in more sunlight east of them than west of them. One location may have a history of severe hail storms while another only a quarter of a mile away may have had no such storms.

A greenhouse should be located part way down a slope to avoid strong winds at the tops of hills and to also avoid still air that often prevails in "bottom" land.

Water of good quality and in sufficient amount must be available to a greenhouse range.

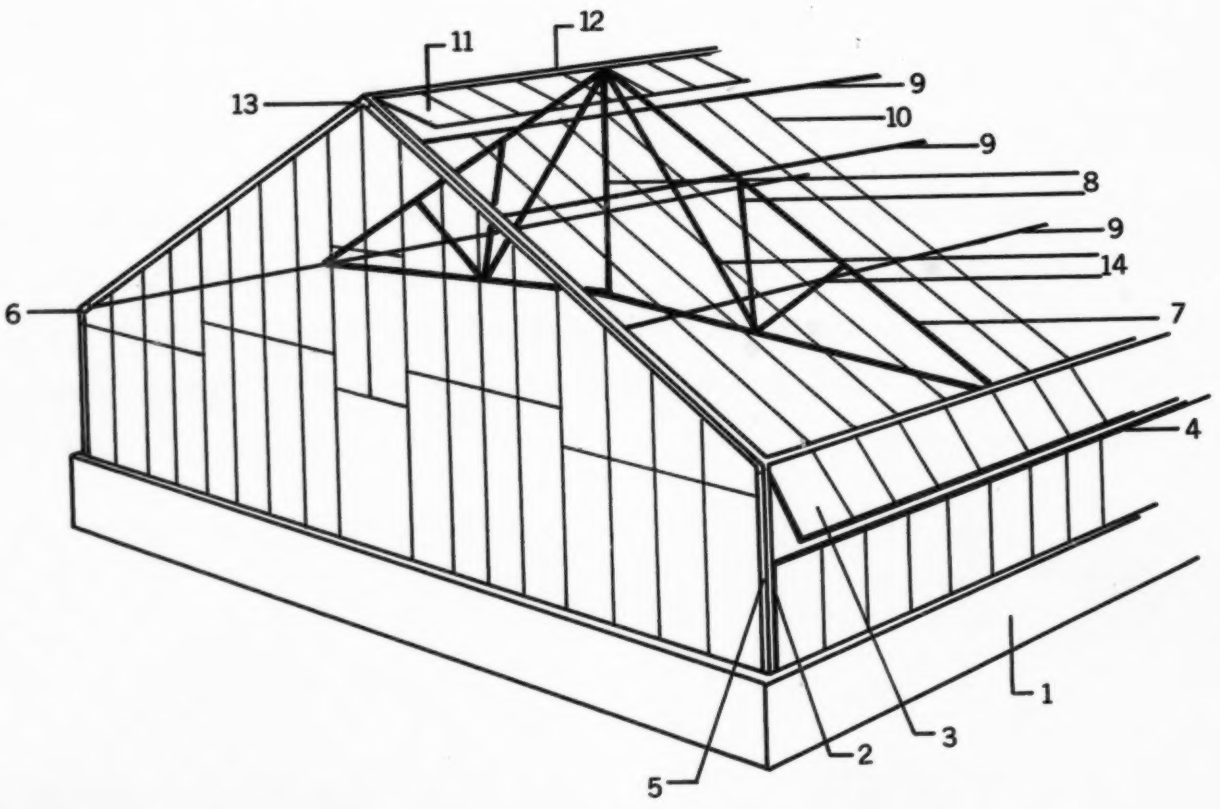
Many greenhouses in the northeastern United States use gas or oil as fuel for heating. The availability and relative cost, as well as dependability, are major considerations in the kind of fuel used. About 17% of the cost of a marketed florist crop is in fuel alone. The availability of electrical power is also important.

Greenhouses can offer employees steady, year-around work, but crops become a total loss if there is even a several-hour interruption in the care of them. Greenhouses tend to locate where labor is available that is likely to be sympathetic to the peculiarities of greenhouse crop production. About 50 to 60% of the cost of a marketed florist crop is in labor.

Taxes are a major concern to greenhouse companies. Many new ranges are deliberately built in small towns or even in rural areas where taxes are likely to remain low enough to allow a reasonable profit.

All of the factors mentioned determine the location chosen for a greenhouse range. Within the last decade, as a result of more efficient and less expensive transportation, a number of cut-flower ranges have actually moved their greenhouses from low winter sunlight locations in the northeastern U. S. to new locations in the high elevations of the Carolinas where the amount of winter sunlight is greater, and summer night temperatures are cool.

Parts of a Greenhouse



1. Sidewall
2. Lower side sash
3. Side ventilator
4. Transom sill
5. Side post
6. Splice plate
7. Rafter
8. Ties
9. Purlin
10. Sash bar
11. Ridge vent
12. Ridge and ridge cap
13. Ridge plate
14. Struts

Figure 2 . The parts of a greenhouse.

The framework of a greenhouse consists of side posts (or gutter posts in the case of connected houses) at about 10-foot intervals, to support the roof trusses. The eave or gutter extends from post to post at the point where the truss joins the side post. The ridge extends from truss to truss at the peak of the house and midway between the ridge and the eave a purlin extends from truss to truss. If the house is wide, two or more purlins may be spaced halfway between ridge and eave. For wide houses or for trusses that need additional support, posts are provided at each truss from the purlin to the ground. See Figure 2 for identification of the parts of a greenhouse.

Usually a curtain wall of concrete or transite is used for about 3 feet high at the base of the side walls of the greenhouse. For glass houses, sash bars are installed approximately 20 inches apart from ridge to purlin to eave, and wall bars are placed from the eave to the sill of the side wall. These bars provide the base for the glass. Houses that are to be covered with film plastic may have bars or rafters spaced about 4 feet apart with wire fabric installed beneath the plastic film to support it. Corrugated plastics should be applied to framework members that run lengthwise to the house. These should be installed about every 3 feet across the width of the roof depending on the width of the corrugated plastic and the pitch of the roof.

In selecting the materials for the framework of a greenhouse, the structural strength, durability, initial cost, and maintenance costs must be considered. Wooden framework is used primarily for temporary or semipermanent structures. Steel framework has been used widely. This, however, requires painting to prevent rust.

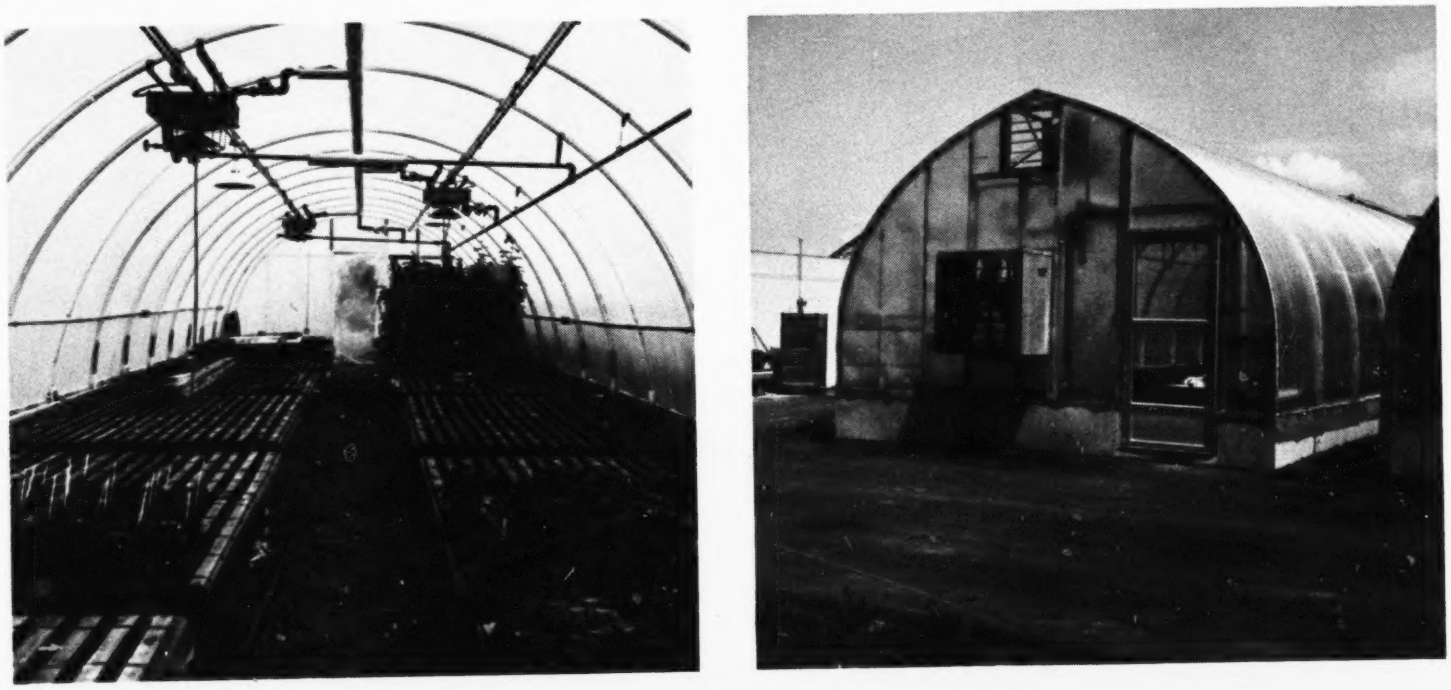


Figure 3 . Temporary greenhouse structures. Left, a quonset type with pipe frame. Right, a Gothic-arch type with laminated wood frame.

Temporary greenhouses with wooden or pipe frames, covered with plastic film or sheets of fiberglass or rigid plastic are often used when conditions are such that permanent structures are not desired.

The roof, wall bars and ventilating sash of a greenhouse may be made of aluminum. The corrosion problem is slight, and the structure does not require painting. So called "Aluminum Houses," however, are more expensive to build than other types.

Examples of greenhouse construction plans and kinds of greenhouses are given in catalogs from greenhouse construction firms.

The Greenhouse Range

A group of greenhouses and other associated buildings on one site are referred to as a "range." The requirements of the crops should be considered before determining the size and arrangement of these greenhouses, head houses, and boiler rooms.

Pot plant crops are grown more easily in smaller houses that have easy access to a central headhouse and shipping room. In such a situation the various temperatures can be provided that are needed for pot plant crops, and movement to and from the potting area, greenhouses, and the shipping room is direct and convenient, (Figure 4).

Cut flower crops are more conveniently grown in larger houses; however, with crops such as chrysanthemums, there is an advantage in having units that can be handled separately.

Economy of construction is important. Ridge and furrow type construction is usually more economical and it requires less land area than separated houses. Some disadvantages are excessive shade from the gutters, lack of good temperature control of individual houses, and inadequate ventilation.

The greenhouses should be arranged so that labor is conserved and the crops handled efficiently. Consideration should be given to the ease with which flowers can be cut and moved to the grading area, and pot plants moved from area to area or to the shipping room.

The benching arrangement as well as the heating and cooling system should be planned while the general layout for the greenhouse is being made. The "peninsular" bench arrangement (see Figure 6) is often used for potted plants because of the great amount of handling involved in growing these plants.

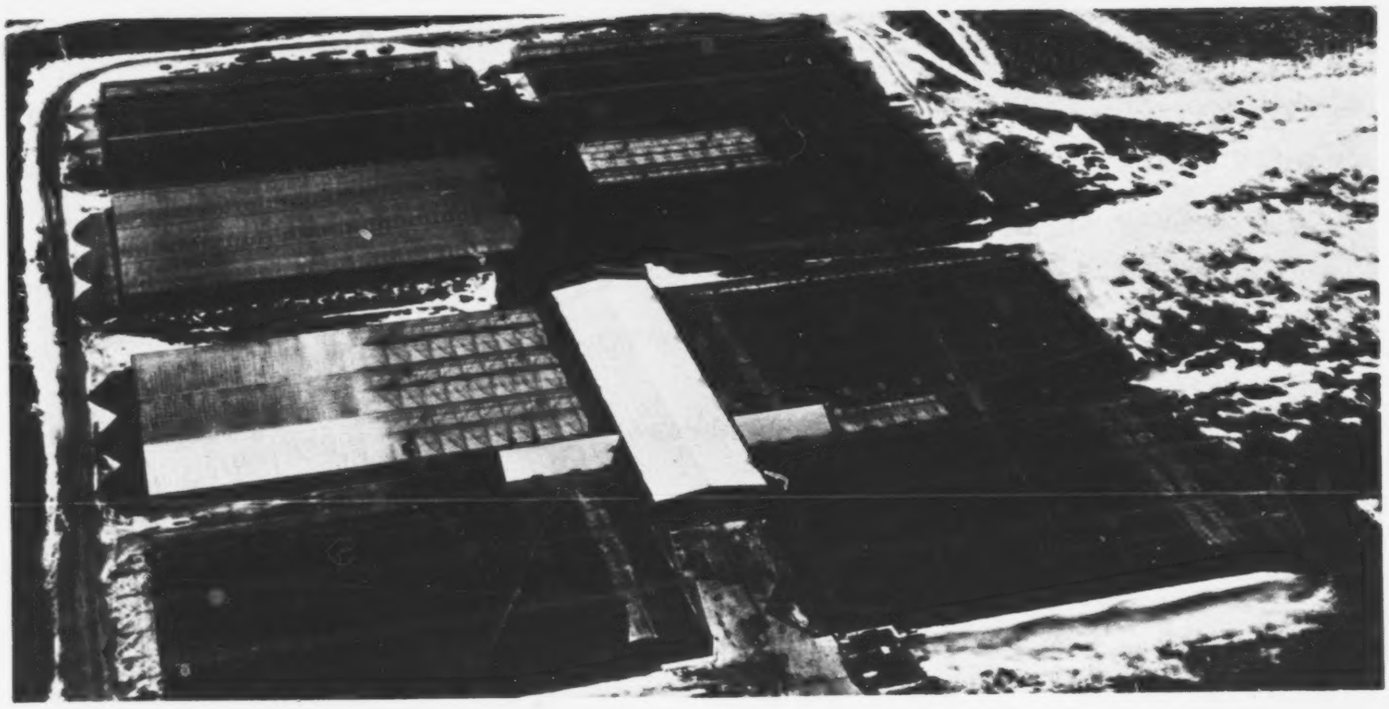


Figure 4. A greenhouse range. (Aerial photo courtesy, Mercer Greenhouse, Inc., Fredonia, Pa.)

Glazing Materials

Glazing materials for greenhouses are selected to allow the greatest possible amount of sunlight for the plants. The durability of the glazing material, the initial cost, and the maintenance costs also determine which material is selected.

Glass - It has been used for many years because a very high percentage of light passes through it. The cost of glass is reasonable, but it is difficult to install, and the periodic reglazing is costly. It is very subject to breakage in those localized areas where hail storms occur frequently.

Glass is placed on the greenhouse like shingles on a roof, except that the panes are lapped only 1/4 inch. They are held in place by glazing points placed at the bottom of each pane, on each side, and also at the top surface at each side. To make the house watertight, the glass is set in bedding compound on the bars, and after the glass is in place, glazing compound is run along each side of the bar and then painted to complete the seal. Aluminum bar caps, especially designed for this purpose, are usually bolted to the sash bars to hold the glass firmly in place and protect the bedding compound and paint from weathering. They greatly reduce maintenance costs. In reglazing, all the glass is removed from the house, the bars are cleaned, and the glass is relaid. Depending upon the condition of the greenhouse, this may be done every 10 to 20 years.

Plastic films - These allow light to pass freely, are economical and are easily installed. The problem is that they do not last very long.

Polyethylene film - The cost of polyethylene film is low, and the installation is easy. The film is available in widths that allow the covering of a roof or possibly an entire structure with a single sheet of film. This film has to be reinstalled every fall. Polyethylene becomes brittle in sunlight and then tears or cracks easily and by late spring it must be removed.

Vinyl film - (polyvinyl chloride, PVC) It is more durable than polyethylene. It may last for a year or longer. It costs approximately twice as much as polyethylene and is produced in widths of 6 feet. It allows more light to pass through than polyethylene when new, but it becomes dirty more quickly.

Mylar polyester film - It allows as much light to pass as does glass. It costs several times as much as vinyl, but it lasts longer. Mylar costs about as much as glass, but installation and maintenance costs may be less. It may be very noisy when a strong wind is blowing.

Fiber glass - It costs as much as or more than glass, but the installation costs are less and the maintenence costs may be less. It gradually becomes cloudy, and after 3 to 5 years, the amount of light passing through it is reduced. Newer formulations are said to remain clear for a longer time.

The humidity is higher in plastic houses than in glass houses because there is less air leakage than in a glass house. Typically, there is more drip in plastic houses. This is due partially to the higher humidity and partially to the nature of the glazing materials and the way it is applied to the structure. Film plastic, of course, is flexible and the condensate scatters off it as the film is jarred or rippled. In fiber glass or rigid vinyl houses, the condensate flows down to the bottom of the corrugation, but it then collects at each purlin or cross member of the structure and drips from that. Electrically operated circulating and ventilating fans are frequently used in plastic greenhouses to help overcome the problem of excessively high relative humidity.

The plastics are not as transparent as glass, so the amount of light passing through them is generally less than through glass. The light passing through plastic is diffused, which results in more light reaching leaves of the plant that would normally be shaded by other leaves in direct sunlight.

Plastic houses generally require somewhat less heat than glasshouses of the same shape and size because of less air leakage.

Coldframes

Coldframes are used primarily for bedding plants during spring hardening off period when they are placed outdoors to toughen them before they are sold, but where they can be protected in case of a sudden frost. They are sometimes used for growing certain plants during the summer.

The coldframe uses only sunlight as a heat source. The heat accumulates in the soil during the daytime and is given off at night to keep the plants warm. Sometimes they are equipped with a steam line for emergency heating. In this case, they are technically "heated" frames.

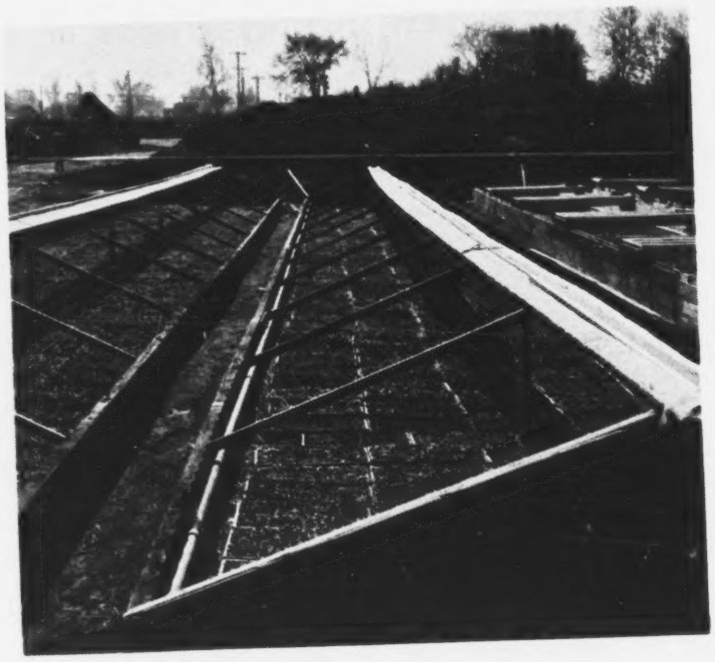


Figure 5 . Coldframes for bedding plants.

The sides of the frames are made of boards or concrete block; and they are 1 to 2 feet high, depending on the height of the plants to be placed in them. Coldframes are made 6 feet wide so that they can be covered easily with the standard glass sash that is 3 feet by 6 feet. The rear wall of the frame is built higher so that water will drain from the sash. Coldframes are inexpensive to construct, but they require considerable labor to operate. They are often equipped with automatic watering devices and machinery for raising and lowering a long row of sash at one time.

Lathhouses

Lathhouses are often used for the production of azaleas and hydrangeas which are plunged in beds for growth during the summer months. Subtropical and tropical potted plants, such as philodendron and sansevieria, as well as "cut greens" are grown in lathhouses in Florida and Puerto Rico. Nurseries often use lathhouses for lining out evergreen stock such as Taxus and broadleaved evergreens.

The 12-foot posts of 4 x 4 inch pine, pressure-treated with copper naphthenate, are spaced 13 feet apart with 3 feet buried in concrete. The stringers are 2 x 6 inch pressure-treated pine boards 14 feet long, nailed on alternate sides of the posts at the top. The slats on the roof are 1/2 x 2 or 3 inch rough cypress spaced 1 inch or less apart. Plastic screen of the proper density may be substituted for the roof slats. The south side is slatted the same as the roof.

One of the best types of structure consists of a permanent frame of pipe or wood at least 7 feet high, on top of which snow fences can be unrolled or lath sash placed when it is needed. When no longer needed, the snow fence is rolled together or lath sash removed, and the plants are exposed to full sun. A permanent structure made by nailing 1 x 2 inch lumber 2 inches apart on a wooden frame is useful, but the plants must be moved in and out.

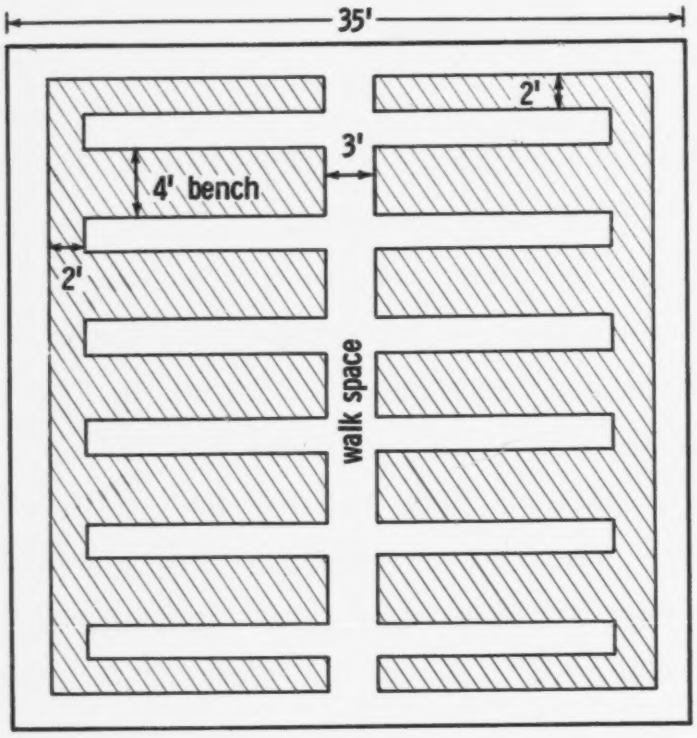


Figure 6 . A peninsular bench arrangement.

Greenhouse Benches and Beds

Before the type of greenhouse is selected and built, a careful study is made of the best bench arrangement in the house for the crops that are to be grown. Upon completion of this study, a greenhouse that will best accommodate this arrangement is chosen. Benches are usually run lengthwise of the house for cut flower crops. If the continuous type of structure is used, the benches may be run crosswise of the houses and be continuous through them. For potted plants, a peninsular arrangement may be used as illustrated in Figure 6. This reduces the amount of walking that employees must do.

If the bench is built directly on the ground, it is usually made from concrete so that it can be completely sealed off from the surrounding soil. Solid bottom concrete benches should have v-bottoms for good drainage and the whole bench should be slightly pitched from one end to the other so that it will drain.

Benches are generally used for potted plant production, while ground beds are preferred for cut flower crops. The benches are usually 30 inches high and 3 to 5 feet in width. It is difficult for people to reach the middle of benches wider than 5 feet. Due to the shading by nearby plants, light becomes a limiting factor near the middle of wide benches. To provide good drainage, raised benches may have solid v-bottoms and drain from one end, or they may have flat bottoms with drainage slots placed frequently enough along the length of the bench to provide good drainage, as shown in Figure 7. The bottom boards for benches made of wood are spaced so that there are about 1/4 inch drainage cracks between boards. With benches made from corrugated transite, it is best to pitch the bottom slightly from one side to the other, and then allow a sufficient drainage space at the low side. More often holes are drilled in the valleys of the corrugations to provide drainage.

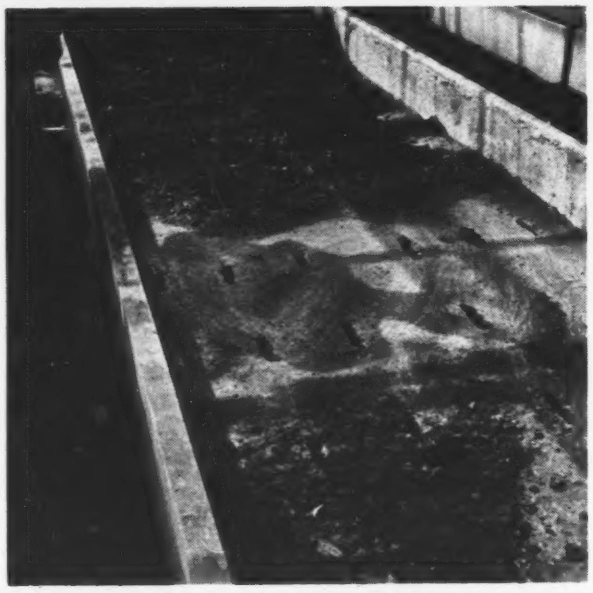


Figure 7 . A concrete bench with slits for drainage.

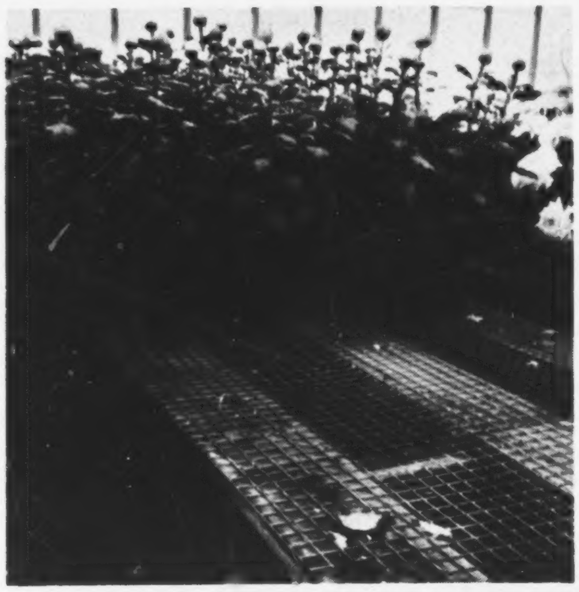


Figure 8 . A wire fabric bench (Courtesy, Geo. J. Ball, Inc., West Chicago, Illinois).

One of the best materials for pot plant bench bottoms is 1 inch by 1 inch welded wire fabric (see Figure 8). This provides excellent air movement around the plants as well as perfect drainage. Many growers believe they can grow superior quality potted plants with this type of bench construction.

The depth of a bench for cut flowers needs to be at least 6 inches. For potted plants side boards are often omitted so there will be better air circulation around the plants.

You may wish to read more about greenhouse structures in Chapter 2, pages 9-35 in Commercial Flower Forcing, Reference No. 7.

Atmospheric Control

A greenhouse is an enclosed space of air, and appropriate handling of this space can result in fairly precise control of the growth of plants within this space. Through the use of the right equipment, the air in the greenhouse may be heated or cooled within one degree of the needed temperature, the relative humidity can be maintained at the desired level, and the carbon dioxide content of the air may be quadrupled to give more vigorous growth of the plants. Another enclosed space, the refrigerator--for holding harvested flowers and plants--also requires precise atmospheric control.

Importance of Temperature Control

Greenhouse air temperature control must be precise to give the proper temperature for each kind of plant and the type of growth desired. Wrong temperatures may cause poor growth or delayed crops.

Generally, plants develop and grow more slowly in cooler temperatures and more rapidly in higher temperatures. Plants are usually shorter and heavier at low temperatures and taller and thinner at high temperatures. Temperature adjustments may be used, therefore, to control the quality of a crop, as well as to induce the crop to flower at a predetermined time, such as for Christmas.

This is discussed more thoroughly under the individual crops.

Heating Systems

The most commonly used heating systems for greenhouses are steam or hot water. From the boiler, hot water or steam is piped to the greenhouses in mains and heating lines in such a way as to distribute heat evenly throughout the entire greenhouse area.

Steam has been used primarily in larger ranges, and hot water in the smaller greenhouses, but it is possible to use closed-system hot water at high pressure and high temperature (above 212°F) as efficiently as steam in large ranges. Steam-heating systems may have a gravity return to the lowest point in the system, with a pump to push the water to the boiler.

The heat pipes are usually placed along the side walls of the greenhouses in four to eight runs of continuous pipe which is arranged in a "trombone" pattern. Additional single lines may be placed about eight feet above every other walk, or may be placed near the benches or beds to one side in every other walk. Figure 9 shows the placement of heating pipes in a greenhouse. Thermostatic controls automatically open and close valves in the system.

Because of the higher temperature of steam, smaller and less expensive mains and heating lines can be used. Heating lines can be heated or cooled more rapidly. Steam can also be transported more efficiently over long distances. Some of the possible advantages of the hot water system are: (1) the water temperature can be adjusted as needed, (2) less water treatment is required as no makeup water is added, (3) no traps are needed, (4) the temperature of the heating lines is more uniform, (5) a licensed engineer may not be required, (6) and hot water will keep the pipes hot longer if the boiler should malfunction.

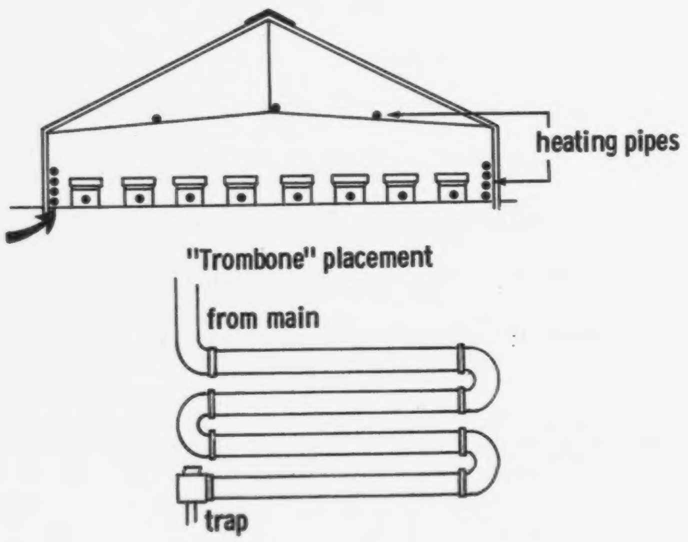


Figure 9 . The placement of heating pipes in a greenhouse.

Unit heaters, flue pipe heaters and other heating devices are also sometimes used in greenhouses.

Heat can be controlled manually or automatically. With manual control of the heating lines, hand valves are used for regulation. By checking the thermometer regularly and activating heating lines as needed by opening or closing valves, the greenhouse can be kept within the proper temperature range. This kind of control requires considerable skill and attention, particularly when weather changes occur rapidly.

In most greenhouse ranges, the steam heating lines are controlled either fully or partially by thermostats and power-operated valves.

Temperature control in the greenhouse with a hot-water heating system is attained by regulating the temperature of the water and by the use of electric, motor-driven water circulators. In mild weather, water temperatures only 10° to 20°F above air temperature may be used, and in cold weather the water temperature may be increased to 180°F in an open system or as high as 220°F in a closed pressure system. The water circulators are activated by thermostats, and when heat is required in a given area, the circulator pumps the hot water through the pipes in that area.

Cooling Systems

Most greenhouse plants stop growing when the air temperature goes above 90°F as it may for prolonged periods in the summer. Two cooling systems, the "fan and pad" system, and the "mist" system are used for cooling greenhouse air.

Washed-air cooling (fan and pad) as practiced today is an application of the old idea of cooling air by drawing it through a wet pad. The cooling effect is achieved through evaporation of water (not by drawing warm air over cold water). By this method the air temperature in a greenhouse might be reduced from 95°F to 75°F with the system in operation.

In greenhouses, most cooling systems consist of large pads of excelsior erected along the entire side or end of the greenhouse. They are kept wet by a constant flow of water from water troughs installed above them -- with holes every few inches which drop water onto the pads. (See Figure 10.)

Air is drawn through these pads by large fans on the opposite side, or end, of the greenhouse. The ridge ventilators and all side ventilators except those outside the pads are closed, so when the fans are turned on, air is drawn through the pads, across the house, and out through the fans.

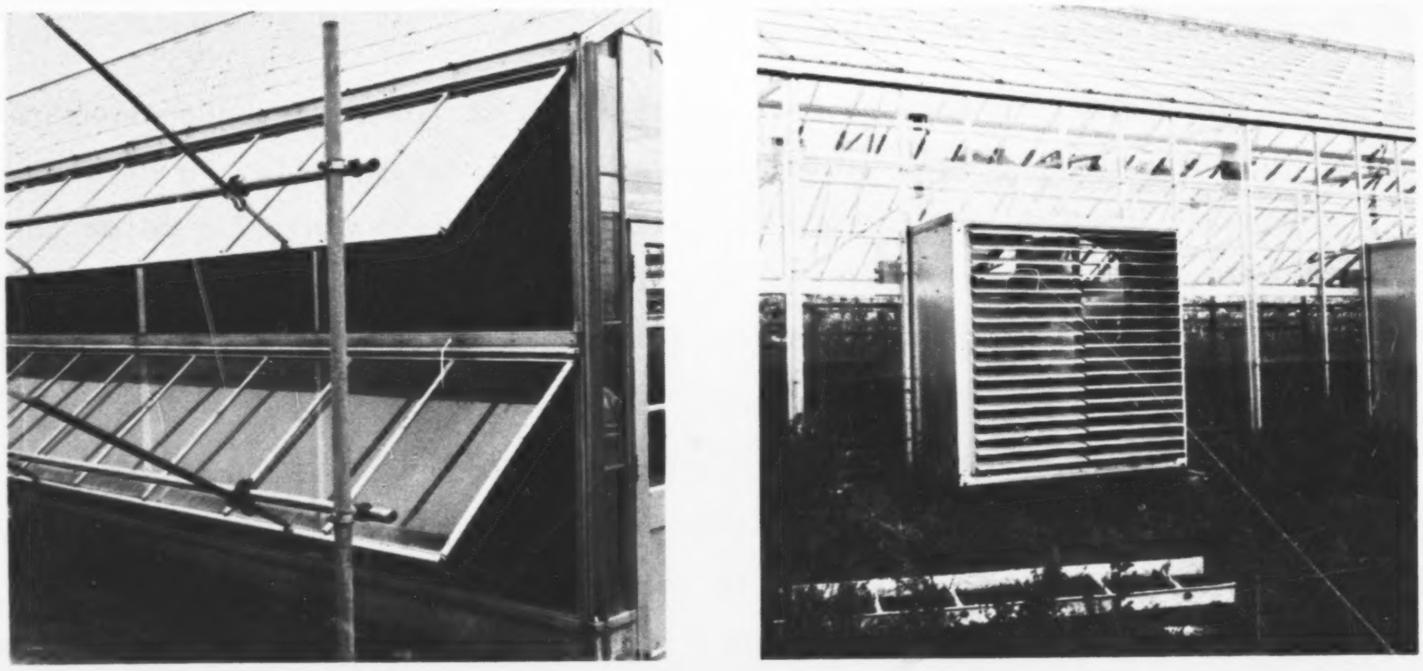


Figure 10. Evaporative cooling. Left, the wet pad in one wall of a greenhouse. Right, fans in the wall opposite the pad.

As the moisture from the pads evaporates, heat is taken from the air as it enters the greenhouse. This cooler air lowers the temperature in the greenhouse. During the night the exhaust fans may be used for air circulation and ventilation, but the water for the pads is shut off to avoid increasing the relative humidity to an unfavorable level.

Mist systems for cooling must provide mist that is fine enough to evaporate without any fall-out of water on the plants. This requires a water pressure of 500 pounds per square inch or higher, with nozzles spaced regularly throughout the greenhouse. Roses respond better to this method of cooling than do most other greenhouse crops, so it is most frequently used for them.

A special shading compound is often applied to the outside glass surfaces to help reduce inside air temperatures. Even a light application will often lower air temperatures by about 10°F. This material is usually applied in mid-April and is removed in early September.

You may wish to read more about greenhouse heating and cooling in Chapter 3, pages 36-62 in Commercial Flower Forcing, Reference No. 7.

Ventilation

It is necessary to provide a good means of exchanging the greenhouse air with outdoor air in order to regulate the greenhouse temperature, adjust the humidity, provide air movement around the plants, and introduce new supplies of oxygen and carbon dioxide.

Most older greenhouses have ventilators at the ridge, and separate greenhouses usually have ventilators at the eaves as well. Power equipment is usually used on ventilators so that they are operated by a motor that is activated by a thermostat. The ventilators need to be operated in such a way that there is some circulation of air but no cold drafts directly on the plants.

In some newer greenhouses there are no ridge ventilators. The air is changed entirely by ventilating fans mounted on the ridge or the side walls of the house. In some greenhouses outside air is introduced through an 18-inch polyethylene tube mounted just under the ridge. This allows for gentle mixing of the cool outside air with the warm air inside the greenhouse. See Figure 11.

Often this tube is arranged in such a way that it may provide continuous recirculation of the air within the greenhouse without the introduction of cool outside air when no cooling is needed. This continuous recirculation of the air in the closed greenhouse results in more even temperatures throughout the house, and eliminates pockets of high relative humidity air near leaf surfaces. These air pockets favor the growth of certain foliage diseases. Sometimes large fans especially designed to provide gentle air movement are mounted overhead in place of plastic tubes.

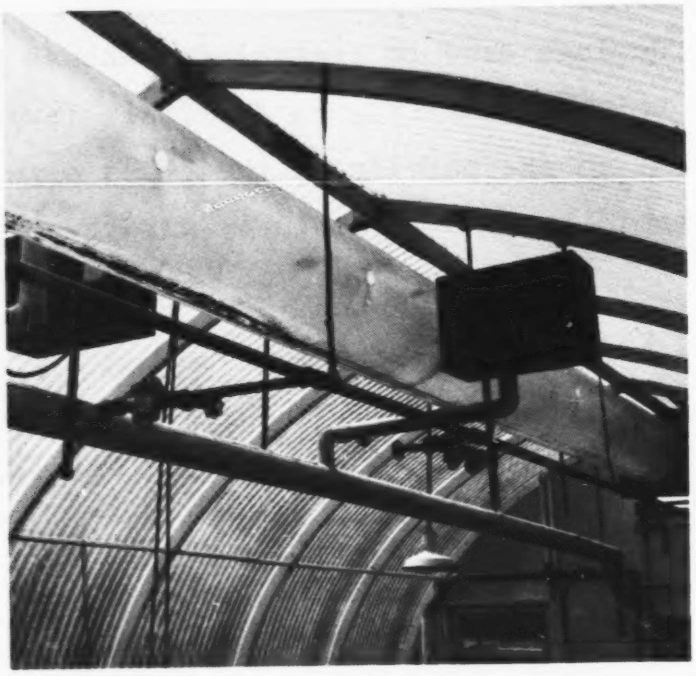


Figure 11. Polyethylene tube for ventilation and air circulation.

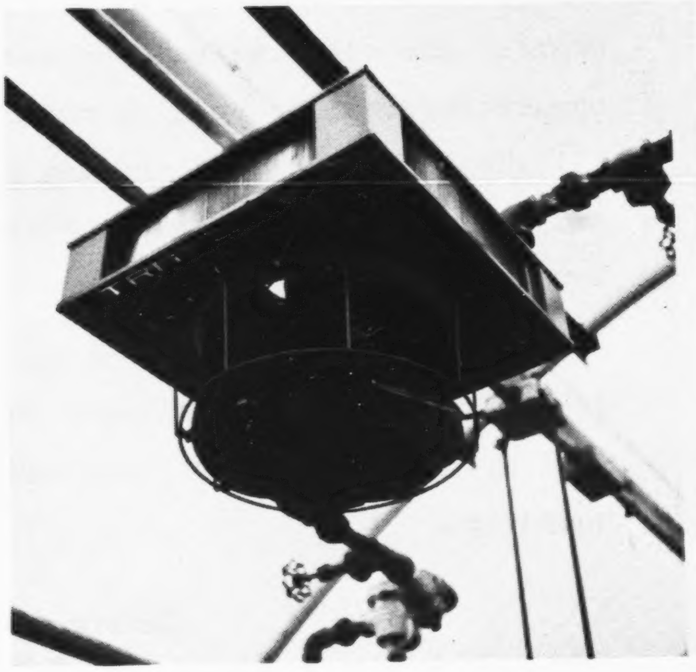


Figure 12. Fan for gentle air circulation with or without heat.

Control of Relative Humidity

Relative humidity is the amount of water vapor in the atmosphere at a given temperature expressed as a percentage of the amount that could be held if the air were saturated. A relative humidity of 70 percent at any temperature indicates that the air is holding 70 percent of the moisture that it could hold at that temperature.

A high relative humidity favors rapid development of some disease organisms, such as powdery and downy mildew. As the temperature drops, the relative humidity increases and with transpiration continuing, a layer of very high relative humidity can accumulate at the leaf surfaces. This layer can be prevented from forming by the use of fans or by ventilation with heat. Turning on a few heating lines in mild weather not only causes a slight rise in temperature, but also accelerates air circulation, which prevents layers of moist air from forming. The use of heat alone, however, is not enough -- it must be coupled with some ventilation. High relative humidity can also be controlled by the use of air circulating fans mounted within the greenhouses as mentioned previously.

In hot summer weather, syringing the foliage and walks by hand will temporarily raise the relative humidity. Unless the foliage and walks are moistened several times an hour, the increase in moisture is temporary. Usually the evaporative type cooling devices used to control greenhouse air temperatures also serve to raise the relative humidity to desirable levels. A light application of shading material on the outside of the glass also aids in maintaining higher relative humidity as well as lower air temperatures.

Maintaining a favorable relative humidity can sometimes become a problem during cold weather when many heating lines are used. The high-pressure mist system can be used, day and/or night, to provide the desired relative humidity.

Carbon Dioxide Enrichment

It has been known for about 75 years that increasing the carbon dioxide available to plants during low-light periods of mid-winter results in improved growth and quality of many plants. Recently, practical means for raising the carbon dioxide level in greenhouses have been developed. The normal outdoor level of carbon dioxide is about 300 ppm; raising this to about 1200 ppm is economically worthwhile.

Recently there have been several types of carbon dioxide generators offered to producers, principally those using propane or natural gas as fuel. Among these are the Tectrol units and the HY-LO carbon dioxide generator. Both of these generators produce carbon dioxide by an efficient low cost method, the oxidation of propane or natural gas.

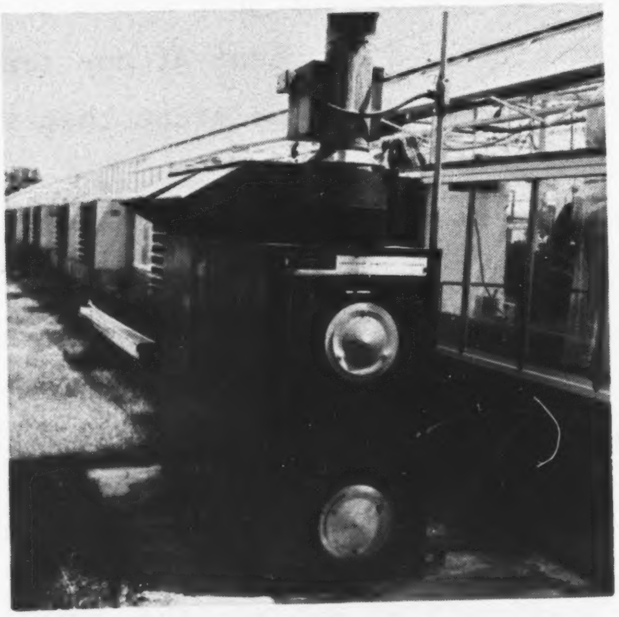


Figure 13. A gas-burning carbon dioxide generator.

Carbon dioxide can also be put into a greenhouse from a liquid or dry ice source that is metered through a flow meter and distributed through plastic tubes or small pipes. Carbon dioxide diffuses readily throughout an enclosed air space. One plastic pipe or tube along the center of a house with 1/8 inch holes at 20 to 30 foot intervals will give good distribution of pure carbon dioxide.

Carbon dioxide levels in greenhouses are increased during the daylight hours from late fall to early spring when ventilation is not necessary for the control of air temperature. Therefore, there is no loss of carbon dioxide due to exchange of inside and outside air.

Roses, grown with increased carbon dioxide levels, show increased production and stiffer stems. Carnation stems are generally stiffer, but flower size and color are not enhanced. Cut chrysanthemums may mature 7 to 14 days earlier, have somewhat larger flowers, and weigh more. Snapdragons may flower as much as two weeks earlier with stronger stems.

Use of Combinations of Atmospheric Controls

The greenhouse atmospheric conditions that can be controlled are temperature, carbon dioxide, and relative humidity.

Each greenhouse crop has a precise night-time temperature at which it grows best. Carnations, for example, are grown at 48°F, 50°F, or 55°F, depending upon the cultivar. Certain roses require 58°F nights while others require 60°F nights for best growth. Night temperatures that are too low for the particular crop may cause a delay in the cropping time and may actually cause nonflowering in poinsettias and chrysanthemums. Precise day-time temperature control is also essential. Day temperatures that are too high may cause "split" carnations and faded roses.

Precise temperature control is obtained by means of thermostatic controls especially designed for greenhouse use. Certain mercury-type switches give control within a fraction of 1°F. One switch may be used to open and close valves for hot water or steam heating lines. Another may be used to open and close automatic ventilators. A third may be used to turn fans on or off in a forced ventilation system.

By setting up a somewhat complicated series of thermostatic controls, it is possible to have a control system that will automatically coordinate greenhouse heating, cooling, ventilating, air circulation, and carbon dioxide injection. The table below indicates schematically how such a system can work.

Table 1 . Control Scheme for Greenhouse Atmosphere

Step of Temperature Needed	Heat Lines	Adjustment Air Circulation	CO_2 (Daytime)	Ventilator Fans	Water in Evap. Pads
Strong heating	all on	on	on	off	off
Medium heating	some on	on	on	off	off
Low heating	few on	on	on	off	off
No change	off	on	on	off	off
Slight cooling	off	off	off	on low	off
Medium cooling	off	off	off	on high	off
Strong cooling	off	off	off	on high	on

At any step in this scheme, the controllers can automatically shift to the next step in either direction to satisfy a changed need. A humidistat could also be "plugged" into the scheme to automatically control the water in the pad (or mist nozzles) when the relative humidity has gone below or above predetermined limits.

Refrigerators

Cut flowers should be stored overnight in water in refrigerators maintained at between 35°F and 50°F, depending upon the kind of cut flower. Some rooted and unrooted cuttings can be kept in good condition for several weeks at 31°F. All bulbs and some plants require a pre-planting period of cool storage in order to flower satisfactorily in the shortest forcing time.

Most greenhouses are equipped with a number of refrigerators. One at 31°F is used for cold storage of certain cut flowers and cuttings. Others at 35°F, 45°F, and 50°F are used for other bulbs, cuttings, cut flowers and plants having specific storage temperature requirements. The size is

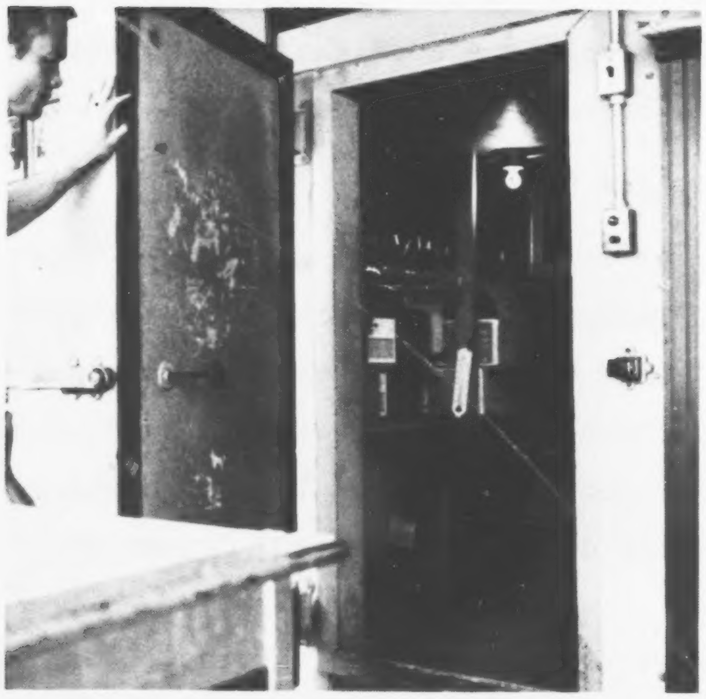


Figure 14 . Greenhouse refrigerators are often used for brief storage of rooted cuttings.

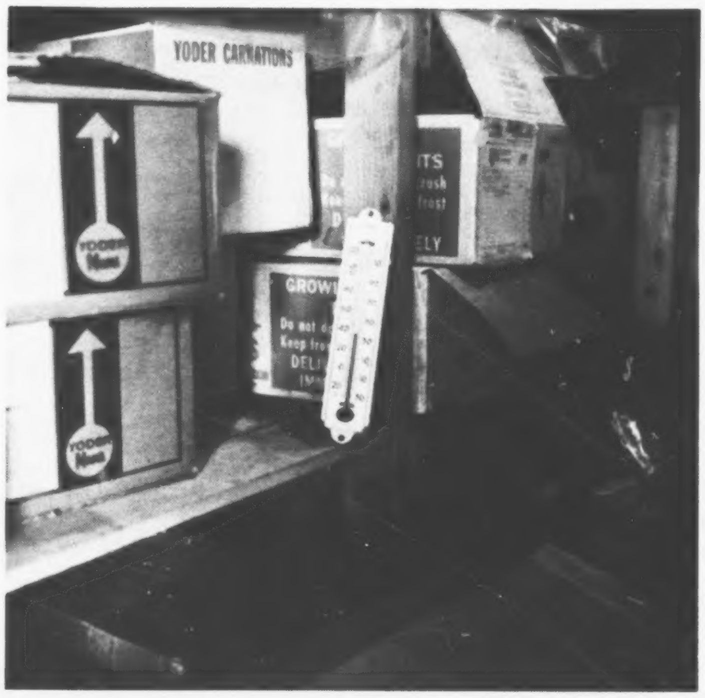


Figure 15. 35°F is a temperature commonly used in greenhouse refrigerators.

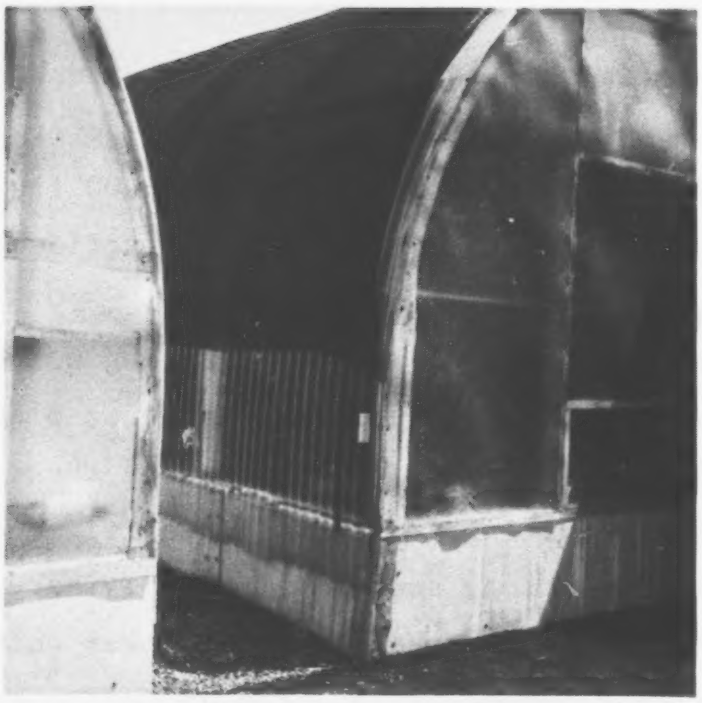


Figure 16. Woven Saran cloth is often used outside or inside greenhouses to reduce midsummer light intensity.

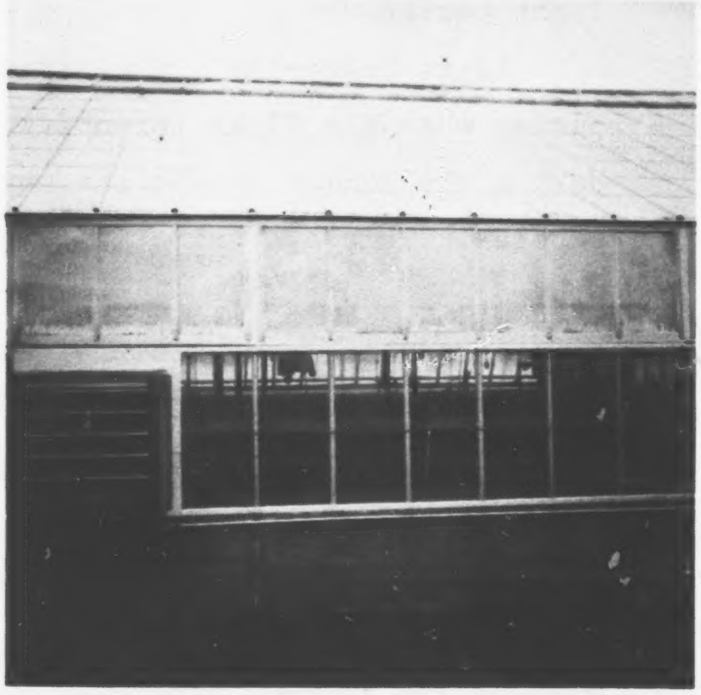


Figure 17. Shading compound is often applied to greenhouses to reduce the light intensity and temperature in summer.

determined by anticipated need. Many new installations are made of prefabricated insulated floor, wall, and ceiling pieces that are bolted together and used with semi-portable refrigerator units.

Light Intensity and Duration

Green plants manufacture sugar in the presence of sunlight. This process is called photosynthesis. Plants are green because of the presence of the pigment, chlorophyll. This pigment when exposed to a sufficient amount of light, combines carbon dioxide and water to produce sugar. Oxygen is released as a by-product. The sugar is then combined with other elements in the formation of cells, tissues and organs of a plant.

Plant growth is affected by light intensity and by photoperiod. The reduced light intensity in winter results in less food being made by the plants; therefore, they are slower growing and less vigorous than in spring, summer, and fall. Length of day (photoperiod) influences whether flowering will occur in certain plants. Poinsettias and chrysanthemums, for example, will only develop flowers when the length of the dark period is more than 14 hours. Roses, on the other hand, flower regardless of the length of the light period.

Light Intensity - Photosynthesis is most efficient in many greenhouse plants when the light intensity is about 6,000 foot-candles. In general during the summer months the maximum light intensity reaches 10,000 foot-candles. This approximation will vary in different areas of a particular state.

In summer, greenhouse plants are shaded by spraying a shading compound on the outside of the glass or by placing muslin, tobacco cloth, or plastic screen above the plants. See Figures 16 and 17. A combination of the two types of shade may be used for plants requiring low light intensities, such as African violets. Plants grown in too strong sunlight typically have short, heavy stems, small light colored leaves, and bleached flower colors. Much of the harmful effect of high light intensity is actually due to high temperature of the plant itself. If the plants can be kept cool with a greenhouse cooling system, the light intensity may be higher with beneficial effect on the growth rate and vigor. Crop recommendations often specify the sunlight intensity appropriate for the particular crop. In northeastern

United States, mid-April is the time to put on the first shade, more may be added in mid-May; some is removed in August, and all should be removed by mid-September.

The term "shade" should be used only in referring to reduced light intensity. The term "shade cloth" is often used in referring to a black, tightly woven material that may be drawn over the plants late in the day to prolong the dark period. "Black cloth" is a less confusing term.

In winter, greenhouse plants, with very few exceptions, require all the sunlight possible if good quality crops are to be produced. Even a light film of dirt on the glass can cut the light intensity in half. Many growers make it a regular practice to scrub the greenhouse glass on the outside once or twice in the fall, and once in mid-winter if possible.

Duration - The chrysanthemum normally flowers in the fall during short days. To induce flowering in this plant in spring or summer, growers artificially shorten the length of day. This reaction of plants to the length of day is called a photoperiodic response. Two commercially important photoperiodic plants are poinsettias and chrysanthemums. For example, cut flower chrysanthemums are usually grown under long days for about four weeks to induce stem growth; then they are shifted to long nights to cause flower buds to set and develop which may take from 10 to 14 weeks. Once color shows in the petals, the long nights may be discontinued.

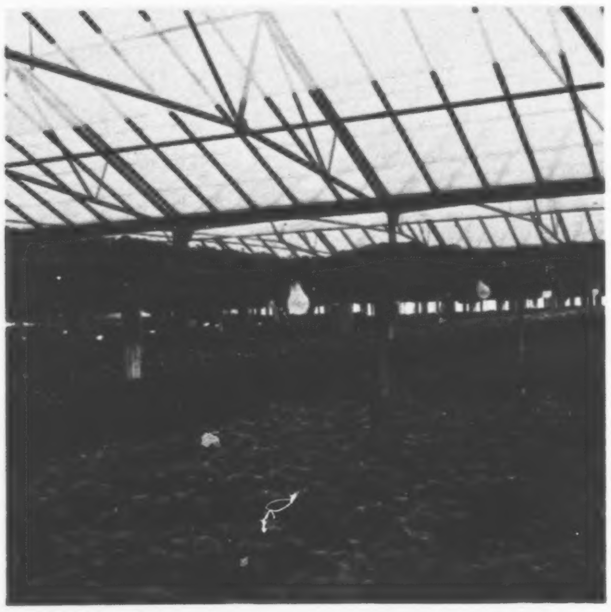


Figure 18. Photoperiod control. Lights for artifically giving short nights. Black cloth used for long nights.

Very low intensity light will effectively increase the length of day for these plants. For most crops, the intensity should be at least 10 foot-candles at the top of the plant. Under normal lighting arrangement, this would be 1-1/4 to 1-1/2 watts per square foot of area covered, including the benches and walks.

Single benches, 3-1/2 to 4 feet wide, will receive adequate light with 60 watt incandescent lamps with good clean reflectors, spaced 4 feet apart and 3 feet above the top of the plants. One hundred watt lamps with reflectors should be spaced 6 feet apart and 4 or 5 feet above the plants. It should be noted that most growers prefer to place their lights high enough to make it unnecessary to move them as the plants grow. The actual light intensity should be checked with every newly planted crop. The light intensity should be measured with a light meter at the tops of the plants farthest from the lights.

Research has shown that it is the length of the dark period, or night length, that affects the photoperiodic response of plants. In winter (when nights are long) if the plants are lighted for only four hours in the middle of the night they will respond as if they had been grown with short nights in mid-summer. Thus chrysanthemums that are given light in the middle of the night in December will grow stems (just as they would in June) instead of the flower buds they would normally grow in a greenhouse in December. See Figure 19.

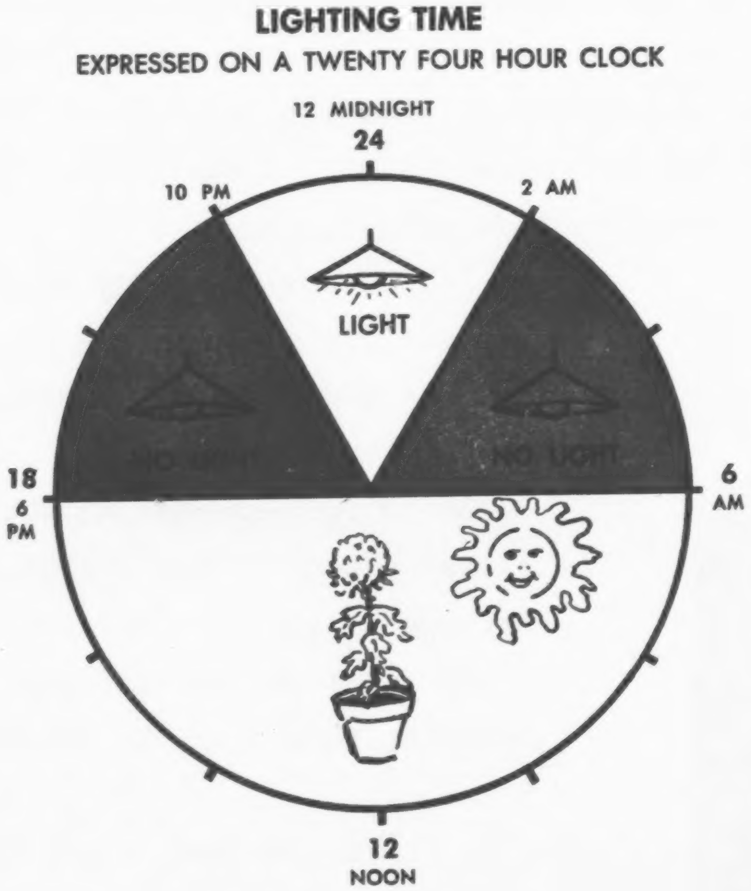


Figure 19. Lighting time expressed on a 24-hour clock. (Courtesy, George J. Ball, Inc., West Chicago, Illinois)

These plants need not be continuously lighted for the 4-hour period. They will respond just as well if lighted for only five minutes in every 20 in this 4-hour period. This requires the use of complex timing devices, but the saving in electricity cost is considerable. This is called "flash" or "cyclic" lighting.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

There are many kinds of greenhouses. It would be advantageous for the teacher to visit as many as he possibly can and examine literature pertaining to the different kinds. Numerous types of equipment are used in greenhouses. Terminology and use of this equipment would be valuable knowledge when talking about greenhouses.

Learning Resources

Supplies - None

References:

Commercial Flower Forcing, Reference No. 7.
The Red Ball Book, p. 109, Reference No. 29.
Catalogs of Greenhouse Construction Firms (see Florist Review or The Exchange for names and addresses)

Audio-Visual Aids:

Greenhouses and Related Structures - Agdex 200/713. 1967. 62 colored slides and script. $9.50. Ohio Agricultural Education Curriculum Materials Service, Room 201, 2120 Fyffe Road, Columbus, Ohio 43210.

Suggested Learning Activities

1. Arrange a class field trip to several greenhouse ranges to familiarize students with the greenhouse structures and equipment.
2. Invite a resource person, physical plant manager of a greenhouse or his representative, to discuss the importance of atmospheric control; e.g., temperature control, heating and cooling systems, refrigeration, humidity control, etc.

Test

1. What market area do producers of potted plants serve?
2. What is the primary purpose of a greenhouse?
3. List two vegetable crops commonly grown in greenhouses?
4. What other primary reason besides market location determines the location of cut flower producing greenhouses?
5. What percent of the cost of a marketed florist crop is in labor?
6. Define the word shade as it is used in this problem area.
7. When sunlight intensities are too low in winter, how do producers compensate for it and why?

8. Make a sketch of the parts of the greenhouse framework. Label all parts.
9. What factors should be considered when selecting the materials for a greenhouse?
10. What do we call a group of greenhouses under one management?
11. Describe a peninsular bench arrangement and cite the reason for its use.
12. How often is reglazing usually done?
13. What is the purpose of coldframes and for which plants are they commonly grown?
14. List three plants usually grown in lathhouses.
15. What are the dimensions of greenhouse benches?
16. At what temperatures do many greenhouse plants stop growing?
17. Explain what is meant by a relative humidity of 70 percent.
18. To what level is carbon dioxide usually raised in greenhouses?
19. Explain the term "fan and pad cooling."
20. Name the two most commonly used heating systems in greenhouses.

PROBLEM AREA 3

ENVIRONMENTAL CONTROL

Learning Objectives

1. To learn about greenhouse irrigation.
2. To learn how to make soil mixtures for greenhouse crops.
3. To learn how to apply fertilizer to greenhouse crops.
4. To learn how to control insects, diseases, and weeds in a greenhouse.

Key Questions

1. What equipment is used for watering and fertilizing plants?
2. What equipment is used for controlling pests in a greenhouse?
3. What are the ingredients of a good greenhouse soil mixture?

New Words

Aerosol - a container that holds a liquid or dust and a propellant

Capillary water - water held in the small soil pores against the force of gravity

Clean culture - free of weeds and debris

Detergent - a non-soap cleaning compound

Dispersed soil structure - soil particles not formed in clumps

Fumigator - a device that spreads a pesticide by means of smoke

Fungicide - a chemical material that kills a fungus

Herbicide - a chemical material that kills undesirable plants

Insecticide - a chemical material that kills insects

Leaching - application of several gallons of water per square foot of area to wash excessive fertilizer through the soil

Pesticide - a chemical material that destroys a pest

Propellant - an inert gas used under pressure to distribute a dust or liquid

Respirator - a device that screens toxic materials from the air

Soil structure - the clumping arrangement of individual soil particles

Spreader - sticker - an additive that causes a solution to spread over a surface and to stick to it

Subirrigation - adding water from below the soil surface

Texture - refers to the size of soil particles, such as sand, silt, and clay

Toxic - a chemical substance that is harmful to plants or animals

Transpiration - loss of water through small openings in leaves

Watering

For the best possible growth of plants, it is essential that they have adequate water at all times. A very high percentage of the water taken through the roots is lost by evaporation through very small openings in the leaves (the process is called transpiration). Much smaller amounts are stored as cell sap or are used in photosynthesis. In addition, about half the water applied to a plant in a clay pot is evaporated from the porous walls of the pot! A potted plant might use as much as 4 cups (1 quart) of water in a single summer day. A rose plant growing in a greenhouse bench could also use as much as 4 cups in a single day. Most plants use as little as 1/4 cup of water on a dull winter day.

An interesting fact about the roots of plants presents practical problems. Although they require an uninterrupted supply of water, they will absorb this water very slowly if they lack an adequate supply of air at the same time. It is possible to have a soil that is completely saturated with water which is not absorbed by the plant because air is lacking. When we say that a plant has been "drowned" we are close to the truth. A plant in this situation may actually be wilting with its roots in water!

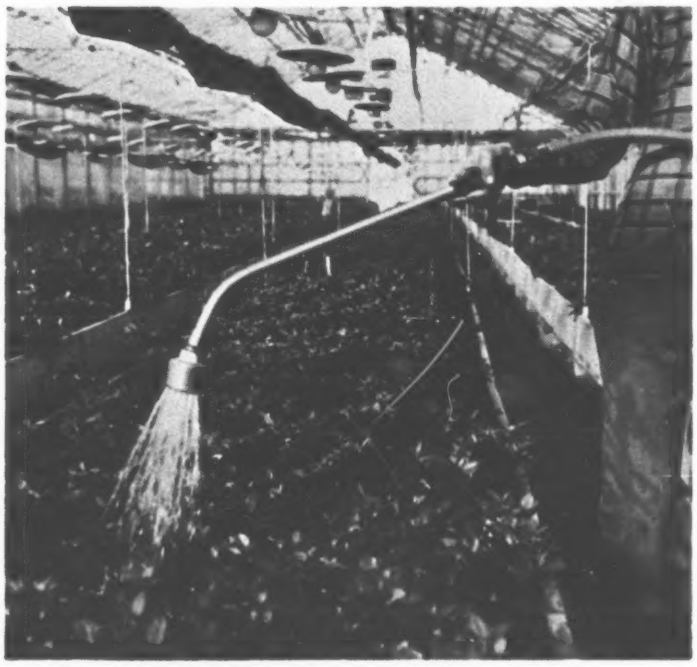


Figure 20. A water breaker is used for applying a large volume of water without washing or compacting the soil.

A soil that holds large amounts of water and air at the same time provides the best conditions for root growth. An example of a soil mixture used for many greenhouse plants consists of 1/4 peat, 1/4 medium grade sand, and 1/2 loam soil. Peat will hold up to 15 times its weight in water, while the sand in this mixture provides open spaces large enough so water will drain from them.

The use of good artificial soil mixtures has eliminated much of the guess work of how frequently to water and what amount to supply. These mixtures make it possible to use semiautomatic equipment for watering plants in the greenhouse.

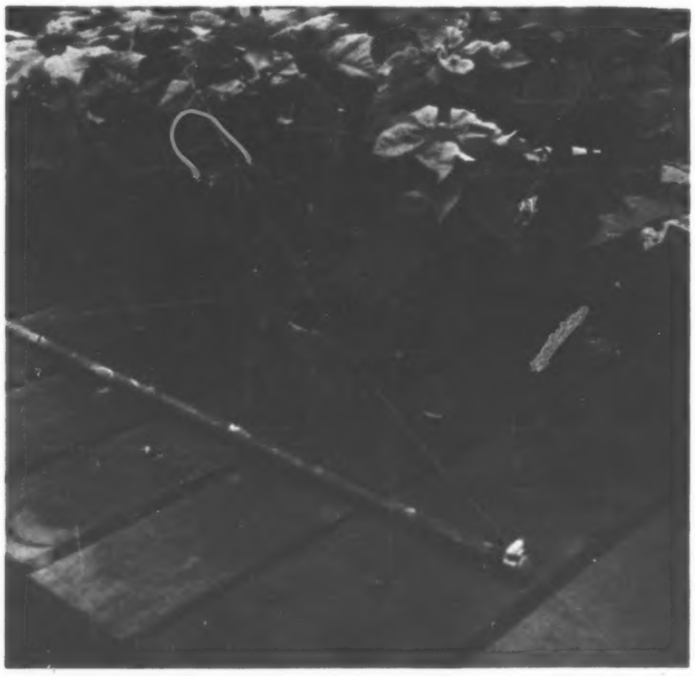


Figure 21. The "spaghetti" watering system for potted plants.

The "spaghetti" system for watering potted plants may be turned on to water from one to several benches of potted plants at the same time. It can be preset to turn itself off after delivering 1 cup of water to every pot. The grower may turn the system on once or twice a day depending upon the needs of the plants. A grower usually tests the soil in a few sample pots several times a day to determine whether water is needed. If the soil is cool to the touch, it is probably moist enough. If it is dry enough to feel warm to the touch, the plants are usually watered at once. Severe wilting may kill or permanently damage a plant. Slight wilting ("flagging") is seldom damaging. The rate at which water is used is governed by the kind of plant, the size of plant, the stage of growth, the weather, and the season. Hand watering of potted plants could take up to 100 times as much time as automatic watering.

The flat spray nozzle system or the perforated plastic tube system are commonly used for watering such cut flower crops as roses, chrysanthemums, carnations, and snapdragons. Figure 22 shows the flat-spray nozzle system. One valve may control the watering of from 1 to 6 benches. About 1 quart of water is applied to each square foot of soil in each application.

The correct amount of water to apply is enough to wet the entire soil volume. If enough is applied so that some of it drains from the pot or the bench, one may be reasonably certain that all the soil is wet. This slightly excessive application of water has the added beneficial effect of helping to wash out excessive soluble materials.

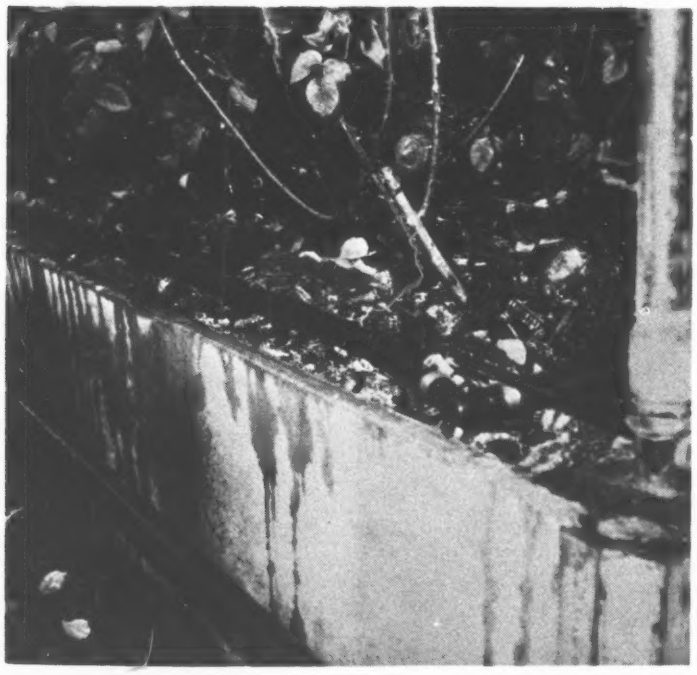


Figure 22. The flat-spray nozzle watering system for cut flowers.

Excess soluble materials ("high salts") are dissolved materials left over from the fertilizer used by the plants. If these salts accumulate in a large enough quantity they can kill the roots of the crop. The soil should be tested monthly to determine the level present. If "high salts" are found, they are washed out of the soil by applying 4 times the usual amount of water in one application. This treatment, called "leaching", might have to be repeated. Unfortunately leaching removes all dissolved materials from the soil, so nitrogen and potassium-carrying fertilizers may have to be added to the soil afterward.

Cuttings and containers of germinating seeds are commonly watered by a "mist propagation" arrangement. This consists of a series of mist nozzles mounted on 2-foot standpipes at about 4-foot intervals down the centerline of a propagation bench. Each nozzle throws a fine mist of water in a flat circular pattern about 6 feet in diameter (see Figure 23). This water is automatically turned on and off by an electrically operated, short interval time clock. This clock operates a solenoid valve in the water line. Usually the time clock is set to turn on the water for 2 seconds in every 2 minutes, but the interval can be adjusted to 5 minutes or longer. The system is operated only during daylight hours (when evaporation is most rapid). It serves to keep the cuttings from wilting until they have formed roots and keeps seed containers evenly moist until the seeds have germinated.

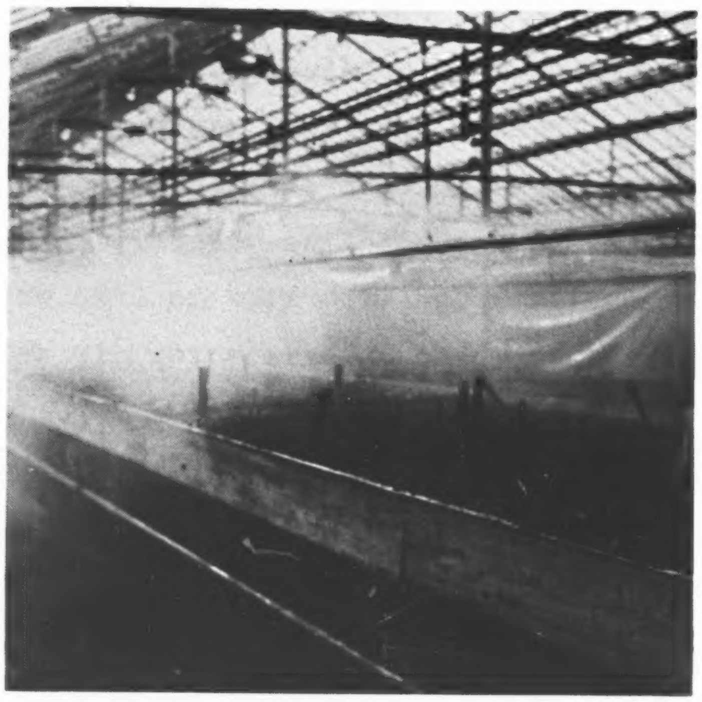


Figure 23. A "mist" propagation bench.

The quality of water varies from one location to another. In some places dissolved materials may be present in such large amounts that the water cannot be used for greenhouse plants. Sometimes certain fertilizer elements may be naturally present in high enough quantity so that none need be added to the soil in which the plants are being grown. Sometimes strongly alkaline water must be acidified for use on such plants as azaleas, hydrangeas, and gardenias. The chlorine and fluorine added to city water supplies for health reasons is not present in sufficient amounts to have any adverse effect on greenhouse plants. Water softeners, however, add sufficient sodium to the water to cause serious problems with greenhouse plants.

Relationship of Soil and Fertilizer

Soil contains a mixture of weathered rock particles and decaying organic matter.

The open spaces in this mixture contain moisture and air, which are essential for growth of plant roots. Good topsoil may not have enough open spaces for best plant growth, so greenhouse soils are improved by adding a material such as peat ("peat moss") to provide more air and water spaces in the soil.

Dissolved minerals in the water provide the nutrients needed by plants. Weathering and the action of microorganisms continuously change insoluble materials in the rock particles and in the organic materials into these soluble materials. Most soils do not contain all of the kinds of soluble materials needed by plants. These minerals may not be present in large enough amounts to permit the most rapid possible plant growth. Tests have been devised for determining the kinds and amounts of minerals present in soil, and on the basis of these tests, additional nutrients may be added in the form of fertilizer. Limestone and superphosphate are often mixed into greenhouse soils when they are being prepared for planting. Fertilizers containing nitrogen and potassium are usually added from time to time while the plants are growing because the plants use these materials rapidly and the soil quickly runs out of them.

The roots of plants, by penetrating the soil, provide an anchor for the plant so it will stand upright -- in this way the soil also serves as a physical support for the plant.

Soil Structure and Texture

A given volume of soil will consist of one-half solids and one-half openings which contain water and air. Ninety percent of the solid portion of soil contains mineral matter.

Soil texture refers to the proportion of sand, silt, and clay. These particles vary in size from the largest, sand, to the smallest, clay. Clay is the active, most important part of soils. The clay particle is negatively charged and absorbs positively charged fertilizer ions which are held rather tightly to the clay particle -- watering the soil will not dislodge the ions. This is a complex process, but in simple terms -- these fertilizer ions can be dislodged for use by the addition of certain fertilizers to the soil. Clay particles are very important to soils. Many persons think of heavy clay soils when the term clay is used, but a good soil should contain certain proportions of clay. Liming is directly affected by clay. Until a large percentage of the adsorptive areas in clay is saturated with calcium, free calcium will not be present in appreciable amounts in the soil solution. Until this happens, there will be little change in soil acidity.

Silt is the next larger size of the three soil particles. The particles are generally too large to have any marked affect on the process of cation exchange previously mentioned for clay. The expression that some silt soils "run like sugar," refers to the fact that these particles do not clump to other minerals within the soil.

Particles of sand have a small surface area and no chemical activity occurs on them as it does with clay. Sand becomes a "framework" in the soil because clay particles may adhere to sand. Sand will increase the size of the spaces between the smaller soil particles, increasing the movement of air and water.

Soils that contain desirable proportions of sand, silt, and clay are called loams such as, sandy clay loams and silty clay loams. When florists use topsoil with the addition of large quantities of organic matter as well as sand, the original soil loses its natural identity.

Soil structure refers to the arrangement of the individual soil particles. When the soil particles are loosely arranged the structure is said to be "dispersed." This characteristic causes the soil to become compact and will not permit the rapid passage of air or water. This condition is often caused by using hoses without breakers to manually apply water to benches over an extended period of time. Granulation is the grouping together of primary soil particles into secondary particles. It is desirable because it draws the particles into close contact, leaving space between the granules.

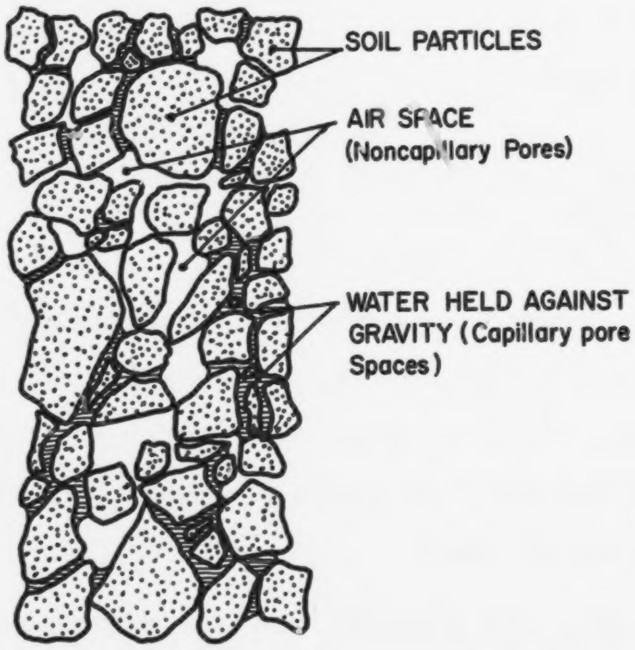

SOIL PARTICLES
AIR SPACE (Noncapillary Pores)
WATER HELD AGAINST GRAVITY (Capillary pore Spaces)

Figure 24. Pore spaces in a soil with good structure.

Spaces between soil particles or granules may be occupied by water or air. These spaces which are small, are capable of holding water against the force of gravity. They are called capillary pores. The water that is absorbed by the roots of most plants is held in the capillary pores. Clay soils are wet and heavy because of the many capillary pores. The larger spaces between granules are called noncapillary pores because water will not rise in them. Noncapillary pores usually are occupied by air unless drainage is poor or water is applied from above, at which time the spaces are temporarily filled with water. Air can move into or out of these pores because water cannot be held against gravity. This is the reason why sandy soils dry so rapidly. The ideal soil contains enough of each kind of pore space to provide adequate moisture and air for the root system and desirable microorganisms. In summary, there are three types of soil water:

1. Gravitational water passes through noncapillary pores by the force of gravity. It is not absorbed to any degree by florist crops because it is not in the soil very long.
2. Capillary water is held in capillary pores against the force of gravity and is available to plants. When soils dry this capillary force increases causing wilting of plants.
3. Hygroscopic water is the moisture that exists in an air-dry soil and is not available to plants.

When soil is placed in a bench or a pot, the effect of the pull of gravity on the shortened capillary columns is lessened as compared to field soils, resulting in wetter greenhouse soils.

Artificial Soil Mixture

Extreme care should be exercised by florists when using any of the materials below. All of these materials and other organic materials, when either incorporated with or mulched on soils, have physical, chemical, and biological effects on the soil.

Organic materials used by florists are:

a. manure
b. peat
c. muck
d. humus
e. corncobs
f. leaf mold
g. peanut hulls
h. sawdust

Cut flowers - grow best in a well-prepared soil which is coarse and porous. Addition of organic matter in the form of peat, chopped straw, or rotted manure will improve the structure. No less than one-fourth organic matter by volume should be added. If heavy soil is used, increase the amount to one-third. Use only the coarser grades of peat.

Potted plants - soils should be coarse and porous, and drain readily. The addition of organic matter such as coarse peat moss, chopped straw, or peanut hulls produces this condition for potted plants. The amounts to add depend primarily on the type of soil used and the specific plant grown.

Seeding - the soil should be well-drained and well-aerated and have high water holding capacity. Topsoil mixed with high proportions of perlite and peat is preferred. A satisfactory mixture can be prepared by combining equal parts of loam topsoil, peat, and sand or perlite.

Foliage plants - most foliage plants grow best in highly organic soils. At least one-half of the soil mixture should be acid peat moss, or leaf mold, and more if the basic soil is fine clay or silt. Some foliage plants are grown in peat only. The majority of these plants do well in acid soils (pH 5.5 - 6.5).

Orchid - these plants require special soil composition depending upon the variety being grown.

Cymbidium - combinations of redwood fiber, fir bark and perlite

Cattleya - mixture of perlite and one of the following: fir bark, Osmunda fiber, or peat moss

Do not pack the media more than necessary. Various bark materials, especially fir bark are substituted for Osmunda fiber.

Fertilizer

Every grower should work out his own fertilizer schedule. Monthly soil testing allows one to formulate his own fertilization program provided water is consistent and the rate of plant growth and time of year are considered. Superphosphate and materials for pH adjustment, such as limestone, should be added to soils prior to planting.

Taking a soil sample, determine the nutrient level in your soil:

1. Obtain a greenhouse soil sample box from a supply house or County Cooperative Extension agent.
2. Scrape away the top 1/8 inch of soil in 6 to 8 separate locations within the area to be tested.
3. Using a narrow trowel or a piece of thin-walled tubing, remove a core of soil from each of these locations. The cores should be uniform from the top to the bottom of the bench.
4. Mix the cores together as your composite sample to put into the sample box. Be sure the box is full, labeled correctly, and that you can identify and associate it with the correct bench location.

5. Send a postcard with each sample, identifying the crop, the fertilizer program, and describing any troubles; be sure to indicate any applications of slow release fertilizers.

Examples of soil test reports are shown on pages 46, 47, and 48.

Fertilizers contain minerals that are essential for the growth of plants. Some parts of plants consist of protein which cannot be made in the plants unless some nitrogen, sulfur, and phosphorous are obtainable from the soil. These materials are given plants in various amounts. Organic fertilizers are composed of plant or animal by-products that break down slowly in the soil. Inorganic fertilizers (salts or chemical materials) are more readily obtained, are less expensive, and are more easily applied.

Fertilizer analysis is the amount of nitrogen (N), phosphorous (P), and potassium (K), contained in a given quantity of fertilizer. A fertilizer with an analysis of 5-10-5 contains 5 percent nitrogen, 10 percent phosphorous and 5 percent potassium, in that order (NPK). Many other materials are usually present in fertilizers such as calcium, magnesium, sulfur, and iron. Fertilizers should be purchased according to price per pound of elements rather than price per bag. Some commonly used fertilizers are given in Table 2, page 49.

Soluble salts are the various ions (potassium, calcium, ammonium, nitrates, sulfates, chlorides, and others) that are in the soil and dissolve readily in water. When the amount of these salts gets too high, they are injurious to plant roots and plants are unable to absorb sufficient water. Plant injuries show up as root injury, chlorosis, stunting, leaf burn, poor seed germination, and slow growth of seedlings or cuttings. High soluble salts come from several sources:

1. overfertilization
2. fertilizer residue
3. water supply
4. soil sterilization
5. watering practice
6. poorly drained benches

Young plants are especially susceptible to injury from excess salts in the soil. Soil for new plantings should always be tested with a Solu-Bridge to determine whether the salt level is within safe limits. This machine measures the electrical conductivity of a water extract of the soil. From the reading obtained, the operator can estimate the soluble salt level in the soil

NOV 26 1968

THE PENNSYLVANIA STATE UNIVERSITY

SOIL TESTING LABORATORY, AGRICULTURAL EXTENSION SERVICE 8-9 49 3
302 ARMSBY BUILDING, UNIVERSITY PARK, PA., 16802 20-34 34- mums
65-66

NOV 26 1968

PLEASE PRINT

Date: NOV 21
Name: RICHARD [illegible]
Street or R. D. No.: RD #1
City: MILTON PA 17847
County: Northumberland
House No. 3 Bench No. 34

This section to be completed by industry only:
Name of Commercial Firm
Street
City

Serial No.
Laboratory No. 9359

GREENHOUSE SOIL TEST INFORMATION SHEET

CROPS

1. Previous Crop ☒ Good ☐ Fair ☐ Poor
2. Present Crop ☐ Good ☐ Fair ☐ Poor
3. Proposed crop or use Cut mums
   - (a) Is this crop planted now? Yes No X
   - (b) If yes, date of planting Stage of Growth
   - (c) If no, proposed date of planting NOV. 27

PLANT GROWTH

If condition of crop is fair or poor describe the type of plant growth.

Vigorous Spindling

Tops:	Dark green	Light green	Yellow	Brown
Top foliage	☐	☐	☐	☐
Lower foliage	☐	☐	☐	☐

Roots: Fibrous well branched ☐ few roots ☐ no roots ☐
Color of fibrous roots: Light ☐ Brown ☐ Black ☐

PREVIOUS FERTILIZER APPLICATIONS

Dates Applied	Analysis of Fertilizer Applied	Rate of Application Per 100 Sq. Ft.
Oct. 10	10-10-10	2 lbs
Sept. 10	10-10-10	2 lbs.

METHOD OF FERTILIZING

☒ Dry ☐ Hozon ☐ Tank
☐ Injector 1:100 ☐ Injector 1:200 ☐ Other

FERTILIZERS I HAVE AVAILABLE: Superphosphate, [illegible], 14-14-14 10-10-10,

ORGANIC MATTER

1. Manure ☐ Peat ☒ Compost ☐ Other
2. Date of last application July 1968

SOIL

1. Square feet of bed or bench this soil sample represents 400 sq. ft.
   What is your total square feet for this crop? 400 sq. ft.
2. Is this new soil? Yes ☐ No ☒
   If new soil, was it composted ☐ field prepared ☐ or no treatment ☐

SOIL STERILIZATION

1. ☒ Yes ☐ No Method STEAM
2. When last sterilized January 1968
3. Will soil be sterilized within a month? ☒ Yes ☐ No

WATERING

1. ☒ Raised Bench ☐ Ground Bed ☐ Potted Plants
2. Drainage: ☒ Good ☐ Fair ☐ Poor
3. Method: ☒ Hand ☐ Automatic (specify)

THIS SECTION FOR LABORATORY USE ONLY

SOIL TESTING 2
PUNCHED

SOIL TEST RESULTS

Texture pH Lime Requirement lbs./Acre
Phosphorus lbs./Acre ppm. Potassium lbs./Acre ppm.
Nitrogen lbs./Acre ppm. Soluble Salts (1:2 ratio)
Calcium lbs./Acre ppm. Magnesium lbs./Acre ppm.

ATTACH
MAGNESIUM
COUPON

SOIL SAMPLING INSTRUCTIONS

GREENHOUSE FLOWERS — VEGETABLES

ATTACH
CALCIUM
COUPON

Unless a representative soil sample is taken, the analysis and interpretation are of no value. Follow these simple directions:

1. Take samples at least 6 hours after watering.
2. Take samples at least 5 days after a fertilizer application.
3. Scrape aside the mulch and top ¼ inch of soil.
4. **Bench Crops:** Take full core of soil from top to bottom of bench with 10 cores or more if necessary, to give a pint sample. Take the cores from spots equally distributed through bench, but **not** within 2 inches of edge or ends of bench.
5. **Potted Plants:** Take samples from top to bottom of soil ball from 10 or more pots.
6. **Potting or Transplanting Soils or Compost Pile:** Take small portions of soil from 10 or more locations in the pile.
7. Spread the pint samples on newspaper in a warm room to air dry over night. Then put the samples in official container supplied with this information blank.
8. Put soil sample information sheet in envelope with first class postage and mail to laboratory. **Before mailing, check serial number on soil sample container against serial number on this blank; they should be the same.**
9. **A Report** of the results of the analyses and the recommendations will be sent to you and your county agent. You may wish to consult your county agent for additional information.

The Soil Testing Laboratory will not test for calcium and, or magnesium unless coupons are attached above. Coupons can be purchased from your local county agent.

Explain any specific problem with this soil.

10450

-48-

12/20/68	9359	1803	NORTHUMBERLAND		3- 34	GHNS MUMS
DATE	LAB NO.	SERIAL NO.	COUNTY	ACRES	FIELD	SOIL

THE PENNSYLVANIA STATE UNIVERSITY
SOIL & FORAGE TESTING LABORATORY
COLLEGE OF AGRICULTURE
UNIVERSITY PARK, PENNSYLVANIA 16802

- SOIL TEST REPORT FOR:

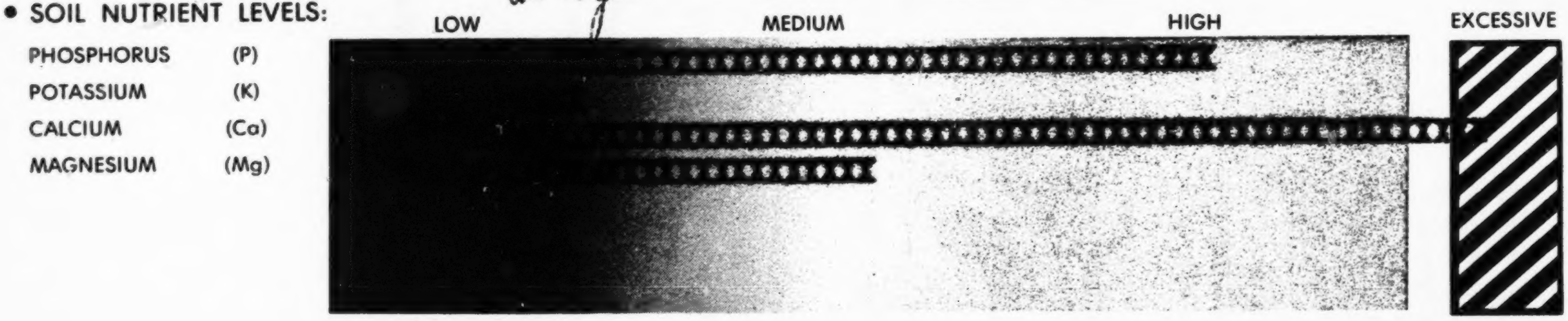
RICHARD L BROWN
MILTON R D 1 PENNA 17847

- LABORATORY RESULTS:

			✓						
7.0	7.0	493	.44	2.95	27.5	30.9	1.4	9.6	89.0
pH SOIL	pH BUFFER	P (lbs/A)	K	Mg (meg per 100 gm)	Ca	CEC	K	Mg % Saturation	Ca

OTHER: NIT-N 439.PPM SOL.SALT 260 too high

- SOIL NUTRIENT LEVELS:



Dear Mr. Brown.

- LIMESTONE AND FERTILIZER RECOMMENDATIONS FOR 11 Dec '68. - Phoned.

Soluable salts & nitrate nitrogen at dangerously high levels.

① Leach soil by applying 2 gal. water / sq ft. Repeat 3 times at 1 hour. intervals.

② Apply potassium sulphate (0-0-48) 1 lb. per 100 sq. ft.

If potassium sulphate ~~nitrate~~ or is not available, use potassium nitrate 13-0-44.

3. No additional fertilizer will be needed for awhile until plants show good growth & light increase Then apply 1 lb 10-10-10 fertilizer per 100 or 8 oz 20-20-20 per 100

INDUSTRY COPY

W. R. Fortney

Table 2 . Analysis and Application Rate of Common Fertilizer Materials

Name of Material	Analysis N-P-K	Application Rate	
		Dry	Liquid
Ammonium sulfate $(NH_4)_2SO_4$	20-0-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Sodium nitrate $NaNO_4$	15-0-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Calcium nitrate $Ca(NO_3)_2$	15-0-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Ammonium nitrate	33-0-0	½ lb. per 100 sq.ft.	1 oz. per 5 gal.
Treble-super phosphate $CA(H_2PO_4O_2)$	0-45-0	2 lbs. per 100 sq.ft.	Insoluble
Superphosphate	0-20-0	5 lbs. per 100 sq.ft.	Insoluble
Urea $CO(NH_2)_2$	46-0-6	½ lb. per 100 sq.ft.	1 oz. per 7 gal.
Mono-ammonium phosphate $NH_4H_2PO_4$	11-48-0	2 lbs. per 100 sq.ft.	1 oz. per 2 gal.
Di-ammonium phosphate (NH_4HPO_4)	21-53-0	1 lb. per 100 sq.ft.	1 oz. per 4 gal.
Potassium nitrate KNO_3	13-0-44	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Potassium sulfate	0-50-0	1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Limestone $CaCO_3$		3 lbs. per 100 sq.ft.	Insoluble
Calcium sulfate $CaSo_4$		2 lbs. per 100 sq.ft.	Insoluble
Ferrous sulfate $FESO_4$		1 lb. per 100 sq.ft.	1 oz. per 2 gal.
Sulfur s		1 - 2 lbs. per 100 sq.ft.	Insoluble
Magnesium sulfate $MgSo_4$		½ lb. per 100 sq.ft.	1 oz. per 4 gal.

Most growers use the liquid fertilization method which is the application of water-soluble fertilizers in solution rather than as dry materials.

The main advantages of liquid fertilizers are ready availability of nutrients, uniform distribution, and savings in labor.

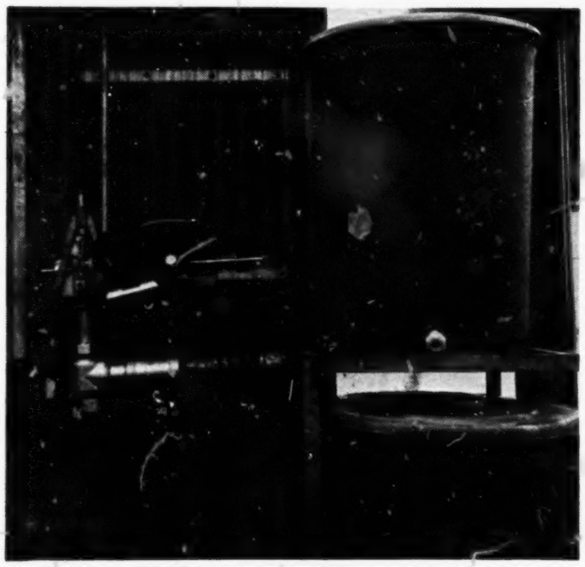


Figure 25. An example of a diluting device for injecting liquid fertilizer concentrate into irrigation water.

When preparing liquid fertilizers, the dissolving tank should be filled with hot (about 150°F) water to insure that all the materials will dissolve. Add the fertilizers to the water and stir until all the solids have gone into solution. A second tank is recommended for mechanical proportioners. Table 3 gives the amount of soluble fertilizer per gallon of concentrate for different levels of fertilization and for fertilizer having different analyses.

Soil pH indicates whether the soil is acid or alkaline. The neutral range is 7.0. Within a range of pH 6.5 - 7.0 applied phosphates are maintained in a more readily available state. Nitrogen and other nutrient elements are more readily released from organic matter. At low pH values crops may be reduced because some elements may be present in toxic amounts. The higher the amounts of clay and organic matter in soils, the more limestone will be required.

Table 3. Commonly Used Formulas and Injection Ratios and Concentrations For Constant Feeding

Use a dosage between 100 ppm and 200 ppm nitrogen. Plant growth and soil tests determine which concentration and formula to use. 1/2 gallon per square foot is normal watering rate with constant feeding.

30% Nitrogen Formulas (30-10-10, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE		
	100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	13.50 oz. (.8437 lb.)	20.25 oz. (1.2656 lb.)	27.00 oz. (1.6875 lb.)
(1:200)	9.00 oz. (.5625 lb.)	13.50 oz. (.8437 lb.)	18.00 oz. (1.125 lb.)
(1:150)	6.75 oz. (.4218 lb.)	10.125 oz.(.6328 lb.)	13.50 oz. (.8437 lb.)
(1:100)	4.50 oz. (.2812 lb.)	6.75 oz. (.4218 lb.)	9.00 oz. (.5625 lb.)
(1:50)	2.25 oz. (.1406 lb.)	3.375 oz.(.2109 lb.)	4.50 oz. (.2812 lb.)
(1:30)	1.35 oz. (.08437 lb.)	2.025 oz.(.1265 lb.)	2.70 oz. (.1687 lb.)
(1:15)	.675 oz.(.04218 lb.)	1.012 oz.(.06327 lb.)	1.35 oz. (.08437 lb.)

25% Nitrogen Formulas (25-5-20, 25-10-10, 25-0-25, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE		
	100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	16.50 oz. (1.0312 lb.)	24.75 oz. (1.5468 lb.)	33.00 oz. (2.0625 lb.)
(1:200)	11.00 oz. (.6876 lb.)	16.50 oz. (1.0312 lb.)	22.00 oz. (1.375 lb.)
(1:150)	8.25 oz. (.5156 lb.)	12.375 oz.(.7734 lb.)	16.50 oz. (1.0312 lb.)
(1:100)	5.50 oz. (.3437 lb.)	8.25 oz. (.5156 lb.)	11.00 oz. (.6875 lb.)
(1:50)	2.75 oz. (.1718 lb.)	4.125 oz.(.2578 lb.)	5.50 oz. (.3437 lb.)
(1:30)	1.65 oz. (.1031 lb.)	2.475 oz.(.1546 lb.)	3.30 oz. (.2062 lb.)
(1:15)	.825 oz.(.05155 lb.)	1.237 oz.(.07734 lb.)	1.65 oz. (.1031 lb.)

20% Nitrogen Formulas (20-20-20, 20-5-30, 21-7-7, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE		
	100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	20.25 oz. (1.2656 lb.)	30.375 oz.(1.8984 lb.)	40.50 oz. (2.5312 lb.)
(1:200)	13.50 oz. (.8437 lb.)	20.25 oz. (1.2656 lb.)	27.00 oz. (1.6874 lb.)
(1:150)	10.125 oz.(.6328 lb.)	15.187 oz.(.9492 lb.)	20.25 oz. (1.2656 lb.)
(1:100)	6.75 oz. (.4218 lb.)	10.125 oz.(.6328 lb.)	13.50 oz. (.8437 lb.)
(1:50)	3.375 oz.(.2109 lb.)	5.0675 oz.(.3164 lb.)	6.75 oz. (.4218 lb.)
(1:30)	2.025 oz.(.1265 lb.)	3.037 oz.(.1898 lb.)	4.05 oz. (.2531 lb.)
(1:15)	1.012 oz.(.06327 lb.)	1.518 oz.(.09492 lb.)	2.025 oz.(.1265 lb.)

15% Nitrogen Formulas (15-15-15, 15-30-15, 16-4-12, etc.)

INJECTOR RATIO	PER GALLON OF CONCENTRATE		
	100 PPM NITROGEN	150 PPM NITROGEN	200 PPM NITROGEN
(1:300)	27.00 oz. (1.6875 lb.)	40.50 oz. (2.5312 lb.)	54.00 oz. (3.3750 lb.)
(1:200)	18.00 oz. (1.1250 lb.)	27.00 oz. (1.6875 lb.)	36.00 oz. (2.2500 lb.)
(1:150)	13.50 oz. (.8437 lb.)	20.25 oz. (1.2656 lb.)	27.00 oz. (1.6875 lb.)
(1:100)	9.00 oz. (.5625 lb.)	13.50 oz. (.8437 lb.)	18.00 oz. (1.1250 lb.)
(1:50)	4.50 oz. (.2812 lb.)	6.75 oz. (.4218 lb.)	9.00 oz. (.5625 lb.)
(1:30)	2.70 oz. (.1687 lb.)	4.05 oz. (.2531 lb.)	5.40 oz. (.3375 lb.)
(1:15)	1.35 oz. (.08437 lb.)	2.025 oz.(.1265 lb.)	2.70 oz. (.1687 lb.)

Pest Control

Importance of Pest Control

Potted plants and cut flowers are acceptable in flower markets and flower shops only if they are free of blemishes. Controlling insects and diseases before they can cause damage to the flowers and foliage is important. Proper handling during harvesting, packing, and shipping, to prevent bruising and breakage , is equally important.

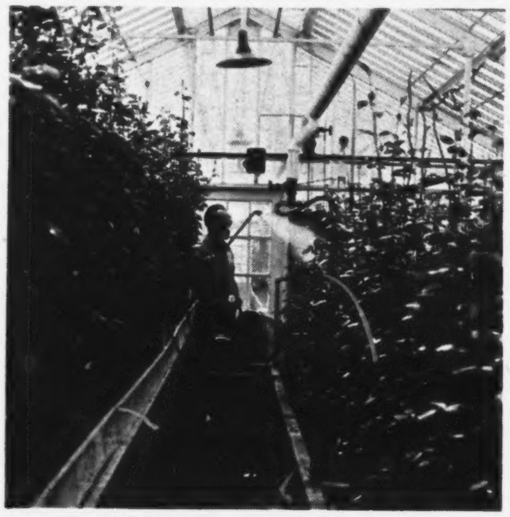


Figure 26. A grower's assistant spraying greenhouse roses for control of pests. (Courtesy, Dept. Entomology Penn State University.)

Weeds and trash are breeding places for a number of pests. These sources of infestation must be eliminated by destroying weeds under greenhouse benches and by maintaining clean greenhouses and work areas. Outdoor areas near greenhouses should be regularly mowed lawns, rather than in tall weeds that are sources of insects and disease.

The prevention of pests before they attack the plants, as in the case of clean culture, will reduce, if not completely eliminate,the expense, time, and effort of controlling them after they become established. Spraying or dusting the plants with materials for controlling pests while the plants are small, and before pests appear, is an accepted standard preventative control measure in greenhouses. Once pests appear, some damage to the crop will occur, repeated applications will have to be made, and more labor will be needed to apply the pesticides.

Equipment and Methods of Control

There are many different methods of applying pesticides and fungicides. Regardless of the method used, the purpose is to get complete coverage of the plant or the pest with the right amount of the control material.

Many of the control materials are toxic to humans and may harm plants. Directions for application must be carefully followed so that the pest or disease can be controlled without damage to the plants. It is very important to avoid endangering the health (or even life) of people working in the greenhouse. Respirators must be worn by workers while dusting or spraying with certain materials. Gas masks must be worn when aerosol applications or fumigation is done with certain materials.

"Open tank" sprayers are commonly used in applying pest or disease control materials in the greenhouse. The control material, usually a liquid or a powder, is mixed with the water in the tank of the sprayer. The sprayer pumps the mixture out in a very fine spray at a pressure of 200 to 400 pounds per square inch. The "open tank" type, in which pressure is maintained in the hose line and the nozzle, but not in the mixing tank, is the kind commonly used in greenhouses. Several manufacturers make models especially designed to fit the narrow walks of greenhouses. To give an even spread of the spray mixture over the leaf surfaces, a detergent, or "spreader-stick" is often used in the spray mixture.

Failure to control pests is more often due to improper spraying methods than to unsatisfactory materials. In order to cover the bottom of the leaves (where insects are usually hidden) the spray should be directed upward from the base of the plant. Spray nozzles especially designed to be used this way are available. If instructions call for repeated applications, it is important that applications be repeated at the recommended interval of days. The interval is based on the egg hatching cycle of the insect, or some other biological rhythm.

If aerosol application is used, the pesticide is purchased in a container called a "bomb." In this container, the pesticide is mixed with an inert gas (propellant) and held at high pressure. This propellant is a liquid under high pressure, changing to a gas when pressure is released. When the valve is opened, the inert gas is released, carrying the pesticide into the air. Aerosol application is usually used for materials that are absorbed by the leaves, rendering the plant sap temporarily poisonous to the pests. Aerosol application is directed as a fine mist above the plants, and is allowed to drift downward onto the plants. The temperatures of the "bomb" and the greenhouse air greatly influence the effectiveness of this control measure, and they must be very carefully controlled. The

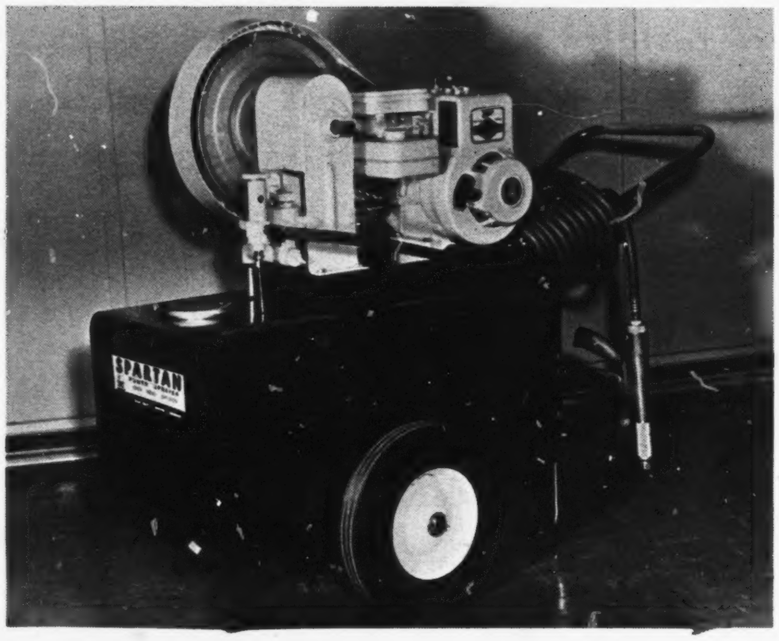


Fig. No. 27 . A greenhouse sprayer. (Courtesy, John Bean Division, FMC Corp., Lansing, Michigan)

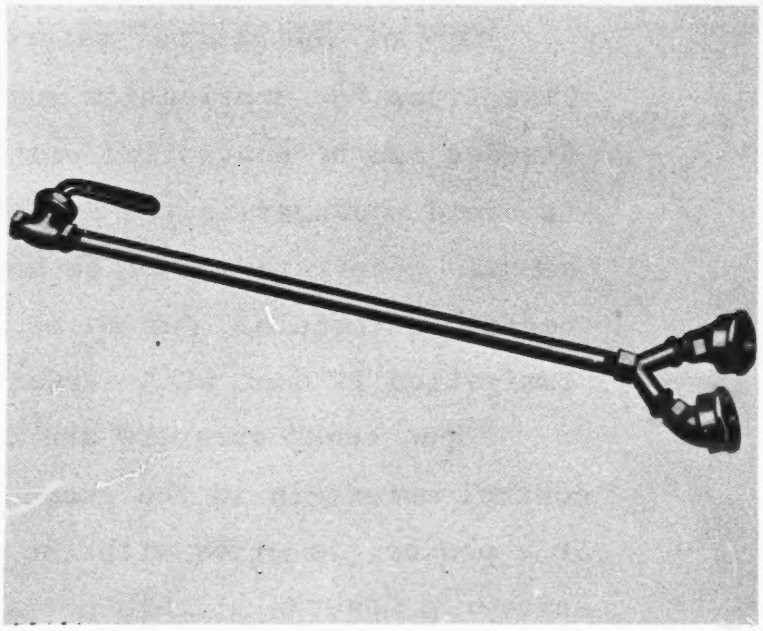


Fig. No. 28 . Spray nozzle for greenhouse use. (Courtesy, John Bean Division, FMC Corp., Lansing Mich.)

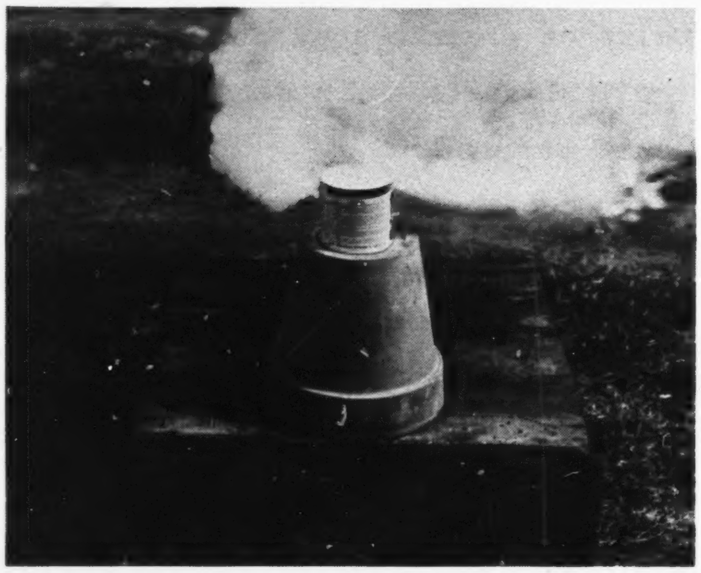


Fig. No. 29. Pressure canister umigation.

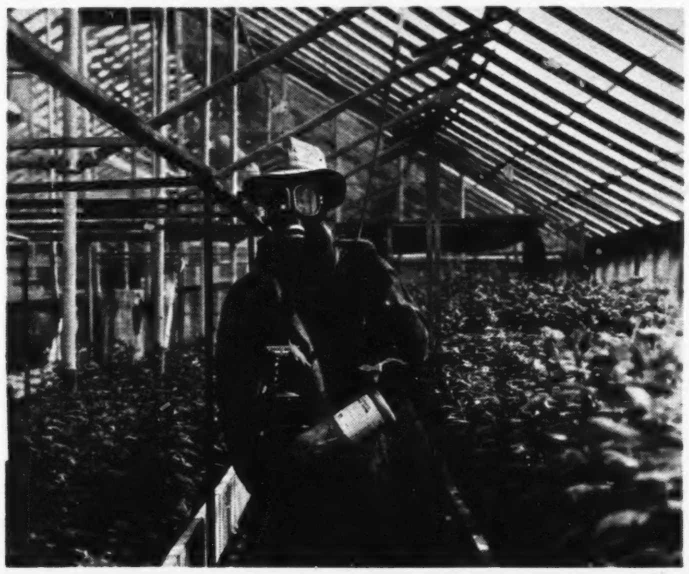


Fig. No. 30 . Aerosol fumigation.

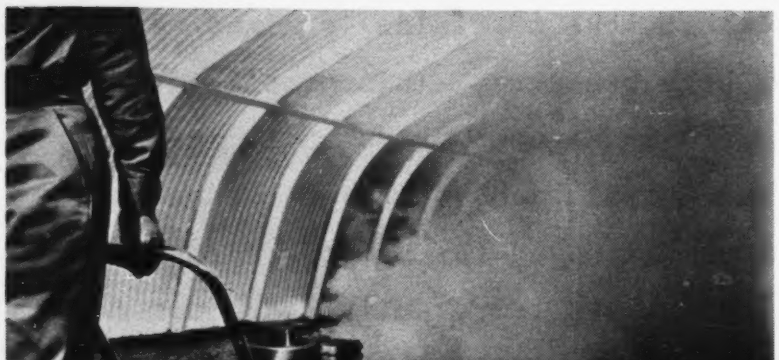


Fig. No.31 . Greenhouse fogger.

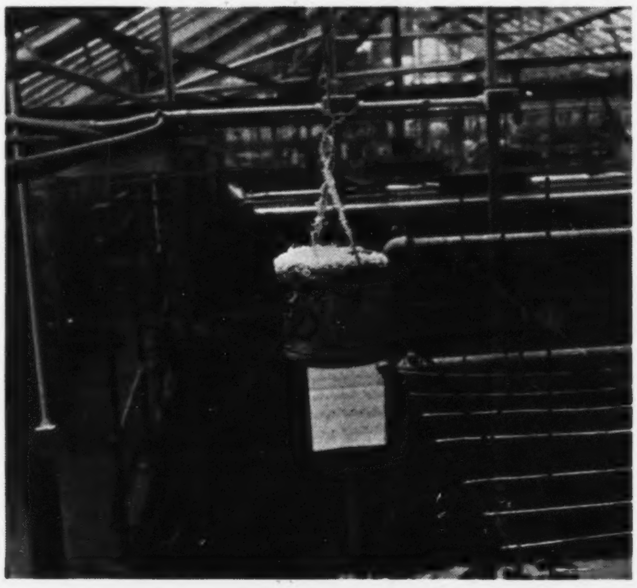


Fig. No. 32 . Sulfur vaporizer for mildew control.

operator walks through the greenhouse for a measured length of time in order to get the right amount of material dispersed for the amount of bench space in the greenhouse. The operator must wear a gas mask as well as special clothing which will prevent absorption of the pesticide through his skin. Aerosol application takes considerably less time than spraying the plants. It also leaves no unsightly residues on the foliage; often an objectionable result when spraying has been done.

Vaporizing certain pesticides from steam lines is economical and a very efficient way to control certain pests. It does not leave a residue on the plants. The control material is painted onto cold heating pipes at the end of a working day, the ventilators are closed, and the valves are opened to allow steam to pass through the heating pipes. In the morning the greenhouse is ventilated by a worker wearing a respirator, and after an hour or two, normal work in the greenhouse may be resumed.

A "fogger" may be used to disperse pesticides that have been mixed with oil. A special machine called a "fogger" heats the mixture and disperses it as a fog in the greenhouse. Oil fog application can be made rapidly and leaves no residue on the plants. However, application by this method cannot be used for all kinds of pesticides, and the oil-based pesticides are expensive.

Pesticides can be applied by fogging or misting or dusting with high velocity air. These are back-pack units powered by a gasoline engine that operates a high-speed blower. The dust is released into the air stream, producing a fine mist or dust. This equipment is efficient, economical, and saves time in application; however, it is bulky to operate through the greenhouse walks.

Pressure canister funigators (often called "smoke" fumigators) consist of pesticides mixed with flammable materials in a can. They are used by punching holes near the top of the can and inserting an igniter that resembles a Fourth of July sparkler. Smoke laden with the pesticide is ejected from the can into the house. Before using them one must calculate the cubical content of the greenhouse, and figure out how many cans of the material are needed for the particular house. Before the fumigators are ignited, the ventilators must be closed. Fumigators are convenient to use, and leave no residue on the leaves. They are, however, comparatively expensive, and not all kinds of pesticides may be applied in this way.

Soil can be made free of insects, disease organisms, weed seeds, and other pests by steaming it at the appropriate temperature for the right length of time. Steaming also makes the soil more porous and thus improves the drainage. A special steam line, that by-passes the heating temperature control, is usually run into each greenhouse for this purpose.

In preparing to steam a bench of soil, the first step is to remove the remains of the previous crop, and its supports of wire and string. If organic material and fertilizer are to be applied, they are added at this point. Then the soil is stirred, usually by a tilling machine, to incorporate these materials and to loosen it to assure good steam penetration. If the soil is dry, it is lightly moistened at this point. A large flexible steam hose is then placed with its open end at one end of the bench, and the bench is covered with a special plastic cloth wide enough to drape over the sides and ends of the bench. The steam valve is then opened just enough to allow steam to slowly develop a bulge under the steam cloth. The valve is then adjusted to maintain this bulge. Under this condition, the steam cloth tightly hugs the bench sides and prevents the escape of the steam. The steam is thus forced to travel downward through the soil. Only about 50 running feet of greenhouse bench can be steamed with one hose. The metal probe of a dial-type thermometer is used to determine when the coolest soil in the bench has reached a temperature of 180°F. Steaming is then continued for 30 more minutes. As soon as the steaming is finished, the cover is carefully (to prevent burning the workers) removed. This allows the steam to escape into the air rather than to condense as water in the soil. Excessive water in the soil will cause a delay in planting the next crop. Plants may be planted as soon as the soil has cooled, which usually takes over night.

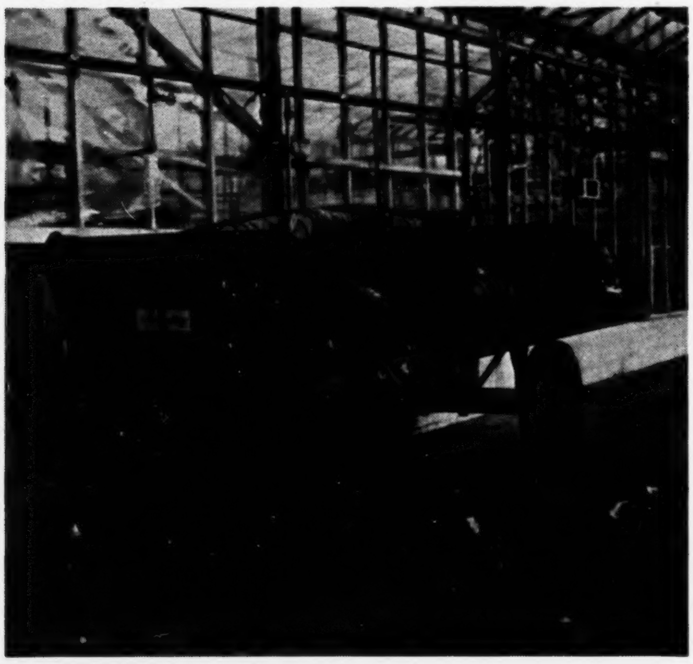


Figure 33. A steaming cart that is also a potting table.

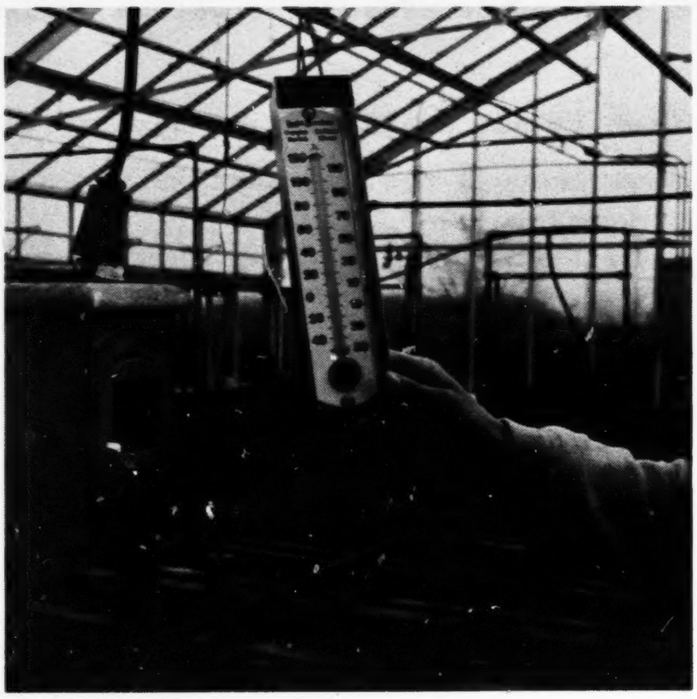


Figure 34. Accurate thermometers, at plant level, shielded from the sun are important greenhouse instruments.

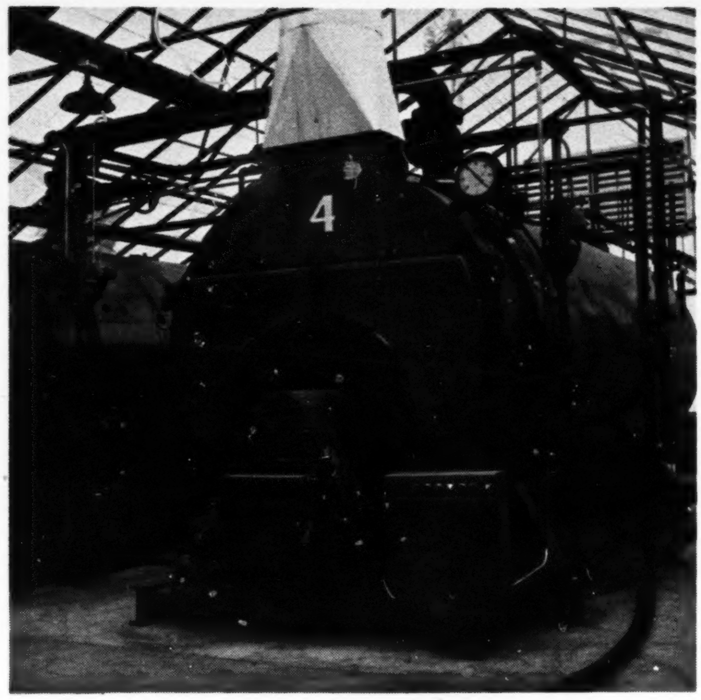


Figure 35. A gas-fired "package" steam boiler.

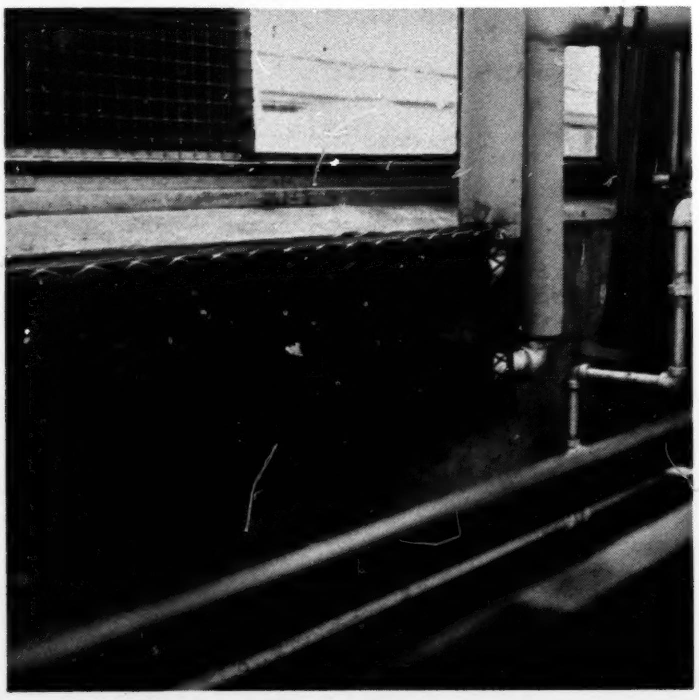


Figure 36. One fin pipe provides radiation equivalent to four ordinary pipes of the same diameter.

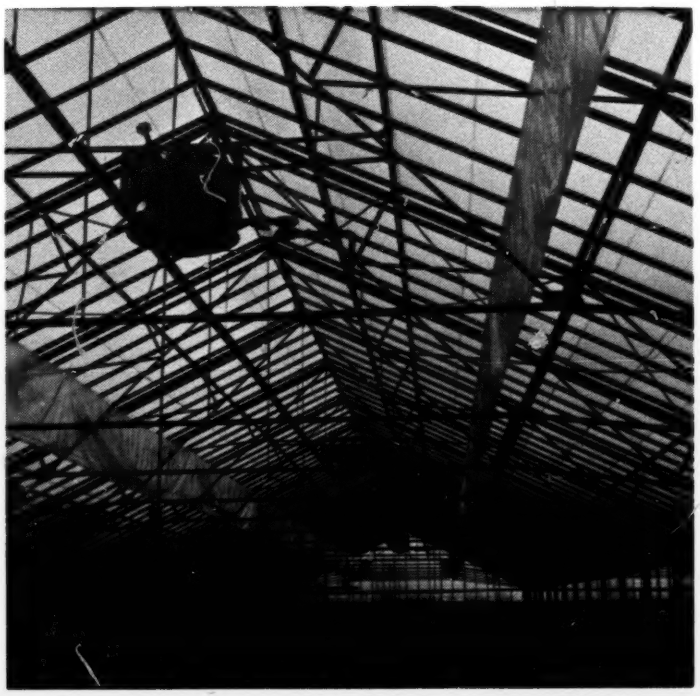


Figure 37. Overhead unit heaters supplement side lines in a large greenhouse.

Steam chests or special steaming tables are used for treating soils to be used for potted plants.

Soil fumigants may be used if steam is not available. None effectively control as many pests as steam, and some leave a residue that is toxic to certain crops such as snapdragons and carnations. The chemicals are either liquids that turn into gases when applied, or they are applied in gas form. For effective fumigation, the soil temperature must be within the proper range. It is recommended that the soil temperature should be 55°F to 75°F for methyl bromide; 65°F to 75°F for chloropicrin; and 60°F to 55°F for Vapam. The soil must be moist and loosened for good gas penetration, and the soil must be kept covered for several days to seal in the gas. The most common materials for fumigating soil are methyl bromide (MD-2), chloropicrin (tear gas), and Vapam.

Insect Control

Two-spotted mite or red spider mite - This is a common pest on chrysanthemums, roses, hydrangeas, and carnations. It is a tiny pest barely visible without a magnifying lens. It is more frequently green than red. Two dark spots can usually be seen on their bodies when they are viewed from above through a lens. Very often the injuries are seen before the red spider mites are noticed. The young and adult suck the juices of the leaves and petals, especially on the underside. The leaves turn dull, gray-green color and they look stiff and straight. Heavily infested foliage turns brown and dries and is usually covered with fine webs spun by these pests.

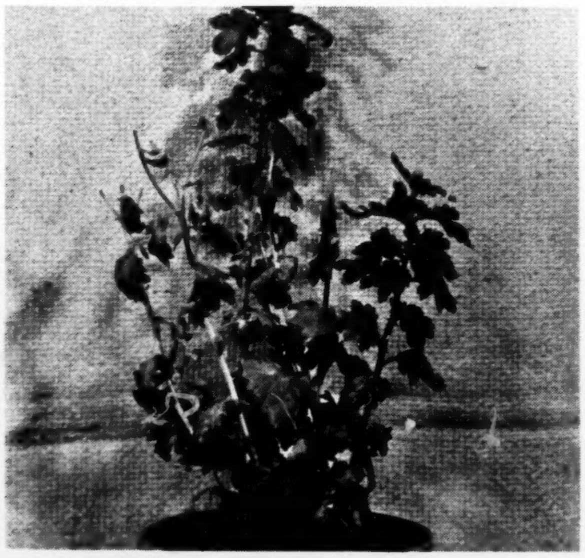


Figure 38. Two-spotted mite injury in chrysanthemum (Courtesy, Dept. Entomology, The Pennsylvania State University).

The female adult lays 2 to 8 eggs per day. These eggs hatch in 4 to 5 days. Two-spotted mite population increase very rapidly in hot, dry weather.

Controls - Pentac 50 WP used at the rate of 1½ pound per 100 gallons of water; Aramite 15 WP used at the rate of 1¼ pound per 100 gallons of water; and Tedion 25 WP used at the rate of 1 pound per 100 gallons of water.

Morestan 25% WP 1/2 lb. or Pentac 50% WP 1/2 lb. per 100 gallons of water as a spray. Thermo-fog machines applying 1/3 oz. of 10% dichlorvos or equivalent formulated in highly refined mineral oil, applied in a sequence of 4 treatments within a ten-day period to 1,000 cu.ft. Houses should be ventilated at the end of 2 hours following each thermo-fogging. Follow all precautions on labels.

Aphids - They infest the upper parts of the stems or the younger growth of leaves or buds. Aphids cause injury by sucking the juices, causing distortion of the tissues. They secrete a honeydew on the foliage in which black sooty mold may grow. Aphids are about 1/8 inch in diameter, with thin legs and soft bodies. They may be green, black, red, or even blue.

Female aphids give birth to living young. They live only 20 to 30 days and can produce 60 to 100 other females which after 6 to 7 days are mature and repeat the cycle. They produce rapidly in moist, humid weather.

Root aphids are grayish in color and covered with a fine powdery wax. They are usually found on the roots of plants,but in heavy infestations they crawl up on the foliage.

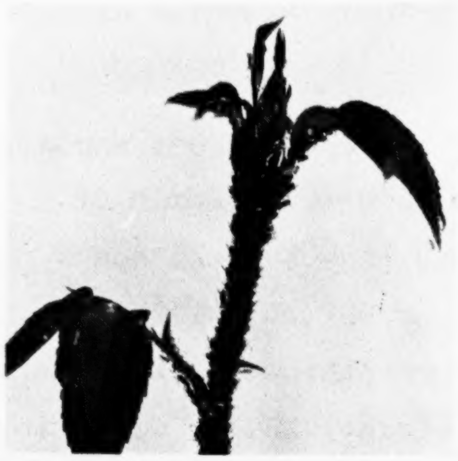


Figure 39 . Aphids on a rose shoot. (Courtesy, Dept. Entomology, The Pennsylvania State University.)

Since ants carry aphids from plant to plant, complete control can only be obtained if both pests are eradicated.

Controls - Meta Systox-R used at the rate of 1-1/2 pints per 100 gallons of water; Dibrom 8 vaporized from the steam lines at the rate of 1 fluid ounce per 10,000 cubic feet; vapona. Diazinon 50% 1 lb., or endosulfan 50% WP 1 lb., or malathion 25% WP 2 lb., or parathion 15% WP 1 lb. per 100 gallons of water as spray. Also nicotine sulfate or sulfotepp may be used as smoke bombs. Follow precautions in handling all materials.

Thrips - During the thrips seasons of early and late summer they are found on roses, carnations, and chrysanthemums. Thrips are slender gray, or cream-colored insects about 1/4 inch in length. These insects move very quickly. To be able to see them it is necessary to dislodge them from the flower by knocking it sharply above a paper. They stay in a shaded or moist part of the flower or leaves.

Thrips cause streaks on the petals and with serious infestations the flowers may be damaged to such an extent that they fail to open. They cause crippling of the flower buds.

Thrips can fly in through the ventilators and reinfest the plants. They can sail with the wind for long distances, and when plentiful, new waves of them reinfest the plants in the greenhouse about as quickly as earlier groups are destroyed.

To control these pests the area must be treated continuously during thrips season. Spray the tops of the plants with dieldrin 18.5% at the rate of 1 quart per 100 gallons of water, or Diazinon 50 at 1 pound per 100 gallons of water. Chlordane 40% WP 2 lb. or DDT 50% WP 2 lb. or lindane 25% WP 1 lb. or malathion 25% WP 2 lb. or parathion 15% WP 1 lb. per 100 gallons of water as a spray. Aerosols include: DDT or dieldrin or lindane or malathion or parathion. Repeat applications are needed. Dibrom 8 vaporized from steam pipes at the rate of 1 fluid ounce per 10,000 cubic feet also gives control.

Greenhouse white fly - It is a seasonal pest on chrysanthemums, tomatoes, and ageratum. This is also the most common pest on poinsettias. The female white fly, which can lay as many as 100 eggs, attaches them to the underside of the leaves in a ring, or circle, on a very short stalk. The eggs hatch in 10 to 12 days into small greenish nymphs which begin sucking the juices of the plant tissue. Four weeks later they become four-winged, white adults, which fly when disturbed. They are the size and color of dandruff. They feed on the plants for a period of 30 to 40 days.

Damage caused by the white fly is the mottling of the foliage similar to that caused by the two-spotted mite. The leaves of the infested plant turn black due to the sooty mold fungus that develops on honeydew in the infested area.

The control of white fly is not difficult, but it should be eradicated in the early stages of the plant's growth. Controls include Thiodan 50 at the rate of 1 pound per 100 gallons of water, Meta Systox-R at 1-1/2 pints per 100 gallons of water, and Dibrom 8 vaporized from the steam lines at the rate of 1 fluid ounce per 10,000 cubic feet. DDT 50% WP 2 lb. or Diazinon 50% WP 1 lb. or endosulfan (Thiodan) 50% WP 1 lb. or lindane 25% WP 1 lb. or parathion 15% WP 1-1/2 lb. per 100 gallons of water as a spray.

Disease Control

Damping-Off - Damping-off causes the death of seedlings. In "pre-emergence" damping-off, the seedling is killed after germination, but before it breaks through the surface of the soil. In some instances the seedlings may fail to appear due to the seed being too old, or the soil temperature being too low for good germination, rather than because of damping-off. In "post-emergence" damping-off, the seedlings break through the soil surface, but several days later they suddenly fall over. In this case, the thread-like mycelium of the fungus grows along the soil surface, punctures the soft tissue of the seedlings and kills them.

Damping-off is so serious a problem with seedlings that most greenhouses use preventative measures whenever seeds are sown. Steaming of the soil (or other medium) at 180°F for 30 minutes, benches and plant containers (usually flats or pots) is done before the seeds are sown. From 1/4 to 1/2 tsp. of Thiram 75%, captan 75%, or Semesan may be added to each 1 lb. seed packet, after which the packet is shaken so that the seeds will be dusted. Seedlings of certain plants, such as Stock, may be permanently dwarfed by the use of these dusts, so they should not be used for every kind of plant. After the seeds have germinated, if damping-off appears in seedbeds and when plants need watering, apply 1 pint per sq. ft. of bed surface Captan 50% WP, 1 T per gallon or Thiram 75% WP, 1 T per gallon or Ferbam 75% WP, 2-2/3 T per gallon or where combination is safe (snapdragons) Terraclor 75% WP, 1 tsp. plus Captan 50% WP, 1 tsp. per gallon or try Dexon 35% WP, 2 tsp. plus Terraclor 75% WP, 1 tsp. per gallon. The surface may be lightly dusted with Ferbam, Captan or Thiram, 5-7%. Gently moving air also aids in prevention of post emergence damping-off by keeping the humidity low at the soil surface. This is done by mounting a fan in such a position that the main blast of air is about 3 feet above the seedlings.

Seed treatment: Thiram 75% or Captan 75% or Semesan 1/4 to 1/2 tsp. per lb. of seed.

Damping-off may be caused by either or both Pythium and Rhizoctonia fungi.

Powdery Mildew - This disease is easily recognized by a powdery white growth, that looks like flour, on the leaves of the plants. It is sometimes confused with a spray residue, but spray residue is more easily wiped from the leaves. Powdery mildew usually occurs on the upper foliage of the plant, and in severe cases, may cause some puckering and wrinkling of the leaves. Rose plants are very susceptible to this disease, and it is sometimes seen on chrysanthemum and snapdragon plants. This disease is most troublesome in the spring and in the fall. The spores of this fungus are very light and float easily through the air. A slight film of moisture on the leaves for several hours gives ideal conditions for the germination of any spores that may land on the leaf.

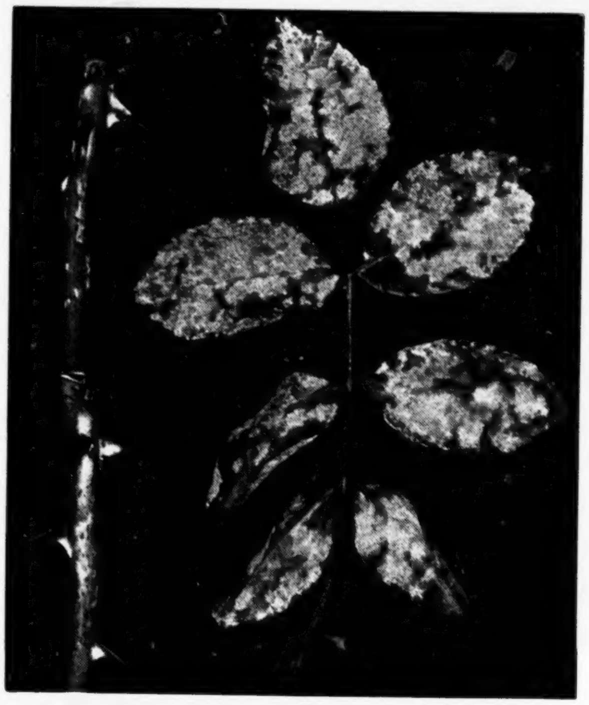


Figure 40. Powdery mildew on rose cane and leaf. (Courtesy, Dept. of Entomology, Cornell University, Ithaca, N.Y.)

Air circulating fans, by keeping the air gently moving, prevent moisture accumulation on the foliage and help considerably in preventing this disease. Many rose producing greenhouses are equipped with continuously operating sulfur vaporizers which put an invisible deposit of sulfur on the rose leaves. This technique gives an excellent preventative control of powdery mildew on roses. Spraying with Karathane, or Actidione PM,gives effective control of powdery mildew for those crops in which this disease is less frequently a problem.

Botrytis - Botrytis blight is a problem especially on chrysanthemums and carnations from spring through fall. It is sometimes a problem with geraniums and tulips. The leaf symptom of Botrytis is brown, dead areas with some yellowing of the leaf. A diseased area of a leaf is often started when a petal from a flower falls on the leaf and stays there. Botrytis may start in the moist area caused by two leaves that are touching each other. This disease can cause rot on stems. Often it starts on cuts or wounds on the stem. Botrytis often attacks flower petals when the air is too moist.

Botrytis on snapdragons occurs on the stem several inches above the soil level. The stem may be entirely girdled and the portion of the plant above the infestation wilts.

To eliminate botrytis organism the soil, benches, and handling equipment should be steamed. Good ventilation and the use of air circulation fans to keep the leaves and stem free of moisture also helps control Botrytis. Wide spacing of plants improves the air circulation around each plant. Old flowers should be removed from the stock plants as often as possible because they are very susceptible to the disease. Remove plant refuse from the greenhouse rapidly to eliminate a breeding place because the disease organism for botrytis grows on old, dying, or dead plant tissues.

Spraying with Zineb 75% WP or Captan 50% WP at 1-1/2 lbs. per 100 gallons of water gives good control. Termil 90% fumigation with 1 eight-gram tablet per 4,000 cu.ft. is also effective.

An excellent reference for identifying insect and disease problems is Diseases and Pests of Ornamental Plants, Reference No. 11.

Weed Control

Weeds in the greenhouse must be controlled without damaging crop plants. Careless use of herbicides may cause twisted, malformed shoots and stunted, unmarketable crops. The fumes of 2,4-D are very toxic to crop plants, and it must never be used in or near a greenhouse.

Herbicides come in different forms: wettable powder, like Dymid, Enide 50W, and Casoron W-50; granular, like Casoron G-4, Chloro IPC 5% and Dymid, and liquid usually in spray forms such as Diquat, Dymid, and Treflan.

Before using weed killers here are some pointers worth remembering:

1. Always read the directions before application.
2. Pre-emergent herbicides kill the weed seeds as they germinate.
3. With preemergence weed killers, the surface must be damp or there should be enough soil moisture. Application may be followed by a light irrigation the same day.
4. A greater amount of herbicide is required to control weeds on a heavy soil than on a light soil.
5. Apply preemergence herbicides in the evening in the summer as high temperatures at the time of application may seriously reduce effectiveness.
6. For effective control apply during the cooler months.
7. Cultivation should be delayed as long as possible after application unless suggested on the directions which is not more than one to two inches. Shallow cultivation may improve the availability of moisture at the time of application.
8. Keep herbicide away from the heating pipes and keep ventilators open during and after applications of herbicide.

Two good references on pest control are:

Fungicides and Nematicides - 1969, Reference No. 16.

Recommended Insecticides and Miticides - 1969, Reference No. 26.

WARNING

Use pesticides only when necessary.

Use pesticides only at the recommended dosages and timing to keep residues on crops and animals within the limits set by law.

Avoid spray or dust drift to other crops and bee yards. Cover food and water containers in livestock areas.

Read the label and follow the safety precautions stated. Maintain a pesticide use record and inventory.

Wear protective masks and clothing if so directed on the label.

Avoid inhaling pesticides. Never eat or smoke while spraying or dusting.

Avoid spilling spray materials on skin or clothing. If spilled, wash off immediately with soap and water.

Wash hands and face and change to clean clothing after spraying or dusting. Wash spray clothing after each day's use.

Store pesticides in original containers and out of reach of children, pets, or livestock and away from food or feed. Keep pesticides in a locked storeroom or cabinet marked "Pesticides -- Keep Out."

Dispose of empty containers so that they are no hazard to man, especially children, and animals.

Do not contaminate streams, ponds, and water sources or otherwise endanger wildlife.

If poisoning symptoms develop from pesticides, medicines, or any other poison source, show your physician a label of the material involved. He can phone one of the Poison Control Centers for complete information as to treatment.

BEFORE USING ANY PESTICIDES READ THE PRECAUTIONS

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NOTICE

Where trade names are used in this publication, no discrimination is intended and no endorsement by The Pennsylvania State University is implied.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Learning Resources

Supplies:

Samples of greenhouse soil
Soil test sample mailing kits
Solu-bridge, either RD-26 or RD-15
Colorimetric pH test kits
Dissecting microscope

References:

Fungicides and Nematicides - 1969. Reference No. 16.

Recommended Insecticides and Miticides - 1969. Reference No. 26.

Commercial Flower Forcing - Seventh Edition. Reference No. 7.

Diseases and Pests of Ornamental Plants - Third Edition. Reference No. 11.

Audio-Visual Aids:

What's in the Bag? (18 min. film), National Fertilizer Association, 616 Investment Building, Washington, D. C.

Watering and Feeding, Agdex 200/15, 1968. 24 colored slides and script. "Constant feed" for greenhouse crops. $3.60. Ohio Agricultural Education Curriculum Materials Service, Room 201 Administration Building, 2120 Fyfe Road, Columbus, Ohio 43210.

Suggested Learning Activities

1. Visit a greenhouse with a class and examine the semiautomatic watering systems in use. Ask the greenhouse manager to give an estimate of the labor saved by these systems contrasted with hand watering.
2. Have the class take soil samples from several crops in the school greenhouse and submit them to the Soil Testing Laboratory at a state university. Discuss the results and recommendations with the class when they have been received.

3. Using a colorimetric method of determination, have every class member determine the pH of a soil sample.
4. Using the section "Operation of the Solu-Bridge," have each student determine the salt level in several soil samples.
5. Have students solve the following problem: Using a Hozon Proportioner device (rated 15:1), how many ounces of a 20-20-20 fertilizer would have to be added to a 10-gallon container (concentrated fertilizer solution) to get 1 oz. per 2 gallons delivery rate at the end of the hose?
6. Have students collect examples of greenhouse insects, diseases, and disorders. Hold a discussion about how to identify the pests, the kind of damage they do, and control techniques used for greenhouse crops. (A dissecting microscope would be helpful.)
7. At this point it would be a good idea to review plant anatomy and plant physiology with students. Pages 63-67 in Commercial Flower Forcing - Seventh Edition, are a concise summary of plant anatomy, while pages 70-78 give a good review of plant response to environment.

Test

1. How can plant roots be supplied with large quantities of both air and water at the same time?
2. Why should a greenhouse crop be given slightly more water than enough to just wet the soil?
3. Why is it necessary to add fertilizer to soil mixtures for growing greenhouse crops?
4. What happens to the plants when the soil contains excess salts?
5. What does a 5-10-10 analysis fertilizer contain?
6. Why is it important to control weeds in and around a greenhouse?
7. Describe how to take a soil sample for a greenhouse crop.
8. Why is it important that applications of spray materials be directed upward through the plants?
9. Why is steaming the best method for controlling soil pests?

OPERATION OF THE SOLU-BRIDGE

Preparation of Soil Sample

1. Weigh accurately 50 grams of air dry screened soil and place in a 125 cc. Erlenmeyer flask.
2. Add 100 cc. distilled water to the flask (this makes a 1:2, soil:water dilution).
3. Shake flask and contents for a 30-second period, 3 times in 20 minutes.
4. Allow to settle for 10 minutes.

The Solu-bridge Machine

5. Plug in cord on machine to 110 volt line.
6. Set switch in upper left hand corner of the Solu-bridge to "ON" position.
7. Allow machine to warm up until "eye" adjustment becomes green.
8. Take temperature of sample with Fahrenheit thermometer, and set the temperature correction knob (located at lower part of Solu-bridge) to the temperature of the sample.
9. Place the electrode into the soil solution and make sure the solution covers the small hole at the top of the electrode.
10. Turn the large dial in the center of the Solu-bridge until the shadow in the "eye" adjustment reaches its widest point. The dial reading is the conductivity value of the sample.
11. Rinse the electrode THOROUGHLY inside and out with distilled water.
12. When through, turn off the switch referred to in Step #6, pull out the cord and place the Solu-bridge back where it belongs.

INTERPRETATION

Solu-bridge readings of soil samples		Salt Concentration	Remarks
Dilution 1:2	Dilution 1:5		
Less than 15	8-25	Low	May indicate insufficient nutrients for most plants.
15-80 (15-180)	25-80	Medium	Favorable for growth of most plants.
80-100 (180-225)	80-100	High	May be associated with slightly stunted condition of some plants.
100-150 (225-340)	100-150	Very High	Associated with slight to severe stunting.
150 plus (340 plus)	150 plus	Excessive	Usually associated with economic failure of the crop.

Preparation of Organic Soil Sample

1. Add 20 gms of peat in a 250 graduate cylinder and add enough distilled water to make up to 100 ml in cylinder.
2. Shake flask and contents for a 30-second period, 3 times in 20 minutes.
3. Allow to settle for 10 minutes and read.

SOLUBLE SALTS - refers to the total soluble mineral element content of the soil at any given time.

OR - excessive soluble salts (saline soils) - refers to a soil that contains sufficient soluble salts to impare its productivity.

Solu-bridge reading of irrigation water	Interpretation
0-25	Excellent
25-75	Good
75-150	Fair
150-200	Permissible
200 plus	Excessive (too salty)

Solu-bridges:

Simplified forms of the Wheatstone bridges are called "Solu-bridges" and are available on the market. Two types are in common use, the RD-26 and the RD-15. They measure electrical conductivity in terms of reciprocal-ohms or mhos/cm. Since the mho/cm is a large unit, a scale reading in the range of salinity injurious to plants would be expressed as small decimals. Therefore, the units have been divided into units called millimhos or by 100,000 into unnamed units. The scale on the Solu-bridge RD-26 gives readings in millimhos (EC x 10^{-3}). Readings obtained on the RD-15 Solu-bridge (EC x 10^{-5}) can be converted to millimhos by dividing the reading from the RD-15 by 100.

An approximate value for the concentration of soluble salts in the saturation extract expressed as parts per million (PPM) can be obtained by multiplying the reading on the RD-26 by about 650, and the EC-15 by about 6.5.

RD-26 · EC x 10^{-3} - expressed in millimhos
RD-15 · EC x 10^{-5} - expressed in 1/100 of a millimhos

Equivalent Measures of Soil Content

RD-26	RD-15	Me	% salt of sat.extr.	ppm. salt sat.extr.
2	200	20	.128	1280.
4	400	40	.256	2560.
8	800	80	.512	5120.
16	1600	160	1.024	10240.

PROBLEM AREA 4

POTTED PLANT PRODUCTION

Many retail customers prefer potted plants to cut flowers because they last longer. Some of the new poinsettia cultivars will last several months in the home -- almost too long! Foliage plants may last six months to a year in the home. Some flowering potted plants, such as geraniums, may be planted outdoors for the summer.

The annual wholesale value of potted plants in the United States is about 100 million dollars. In the northeastern states the most important potted plants are chrysanthemum, poinsettia, Easter lily, azalea, geranium, bedding plants,and foliage plants.

Potted plants are usually sold within 50 to 100 miles of the place where they are produced because their weight makes shipping costs relatively high beyond 100 miles.

This Problem Area is divided into five Units: Chrysanthemum, poinsettia, Easter lily, bedding plants, and a unit consisting of single-page recommendations for the growing of additional potted plant crops.

POTTED PLANTS UNIT 1

Chrysanthemum
(Chrysanthemum morifolium)

Learning Objectives

1. To learn why some cultivars of chrysanthemum are preferred over others.
2. To learn what is meant by the term "week group."
3. To learn how chrysanthemums are grown in rotations.
4. To learn about the cultural requirements of chrysanthemum.

Key Questions

1. What are the different classes of chrysanthemums?
2. Which week group is used for year-around forcing?
3. How are chrysanthemums propagated?
4. How is photoperiod control used for chrysanthemum ?
5. How tall should a chrysanthemum pot plant be?
6. How long does it take to produce a potted chrysanthemum crop?
7. How are potted chrysanthemums fertilized?

New Words

Class - a subgroup of a plant species, having similar shape and size flowers.

Cultivar - cultivated plants that can be reproduced to give a population of identical plants usually given a name to distinguish it from others. A synonym for "variety," but having international meaning.

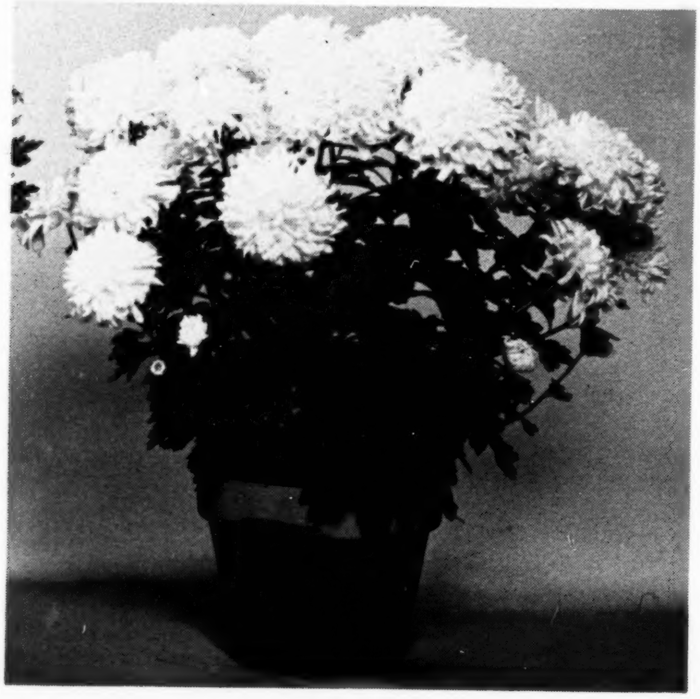


Figure 41. A potted chrysanthemum.

The demand for potted chrysanthemums has increased during recent years. Beautiful, compact, specimens are relatively easy to grow, and, in addition, the chrysanthemum is available in a wide range of colors. It keeps exceptionally well in the home (up to 14 days).

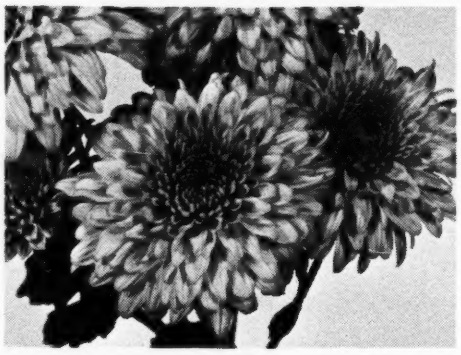
Chrysanthemums are in demand the year around as well as for some of the holidays. This plant is in greatest demand on Mother's Day and Easter. Other high demand holidays are Valentine's Day, Decoration Day, Thanksgiving, and Christmas.

For a more detailed discussion, read Commercial Flower Forcing, Reference No. 7, p. 392, and The Ball Red Book, Reference No. 29, pp. 172-173.

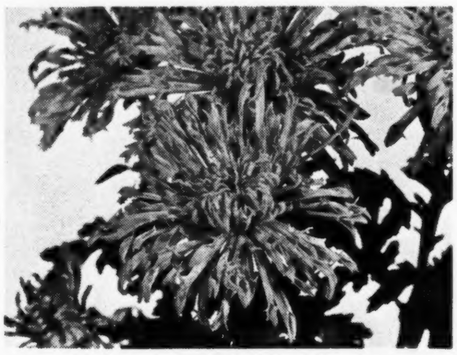
Cultivars

The large-flowered types of chrysanthemums are preferred for pot plant culture because the color effect is better than with the small-flowered types. Some small-flowered "garden chrysanthemums" are grown for spring sales. A compact, dense growth habit is essential. Examples of the classes of chrysanthemums, and cultivars (varieties) within them that are grown commercially as potted plants are listed below and illustrated in Figure 42.

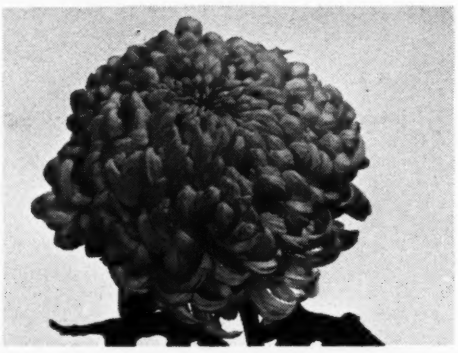
1. Decorative (broad, outward curving petals), Princess Anne, Martian, Tycoon, Bonnafon DeLuxe, Oregon, Bluebird, Telstar.
2. Incurve (petals curving inward over the center of the flower), Indianapolis, Betsy Ross, Mefo, Blazing Gold, Fred Shoesmith.
3. Spider (tubular petals, curled upward at the tips), Tokyo, Silver Strand, Fuji Mefo.



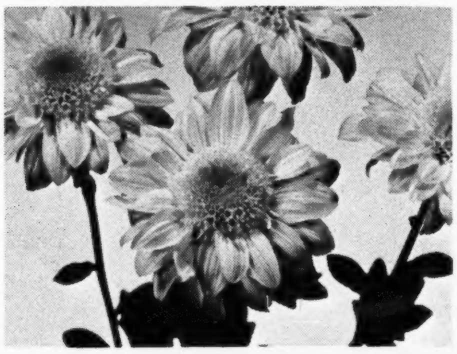
1. Decorative (BGA Telstar)



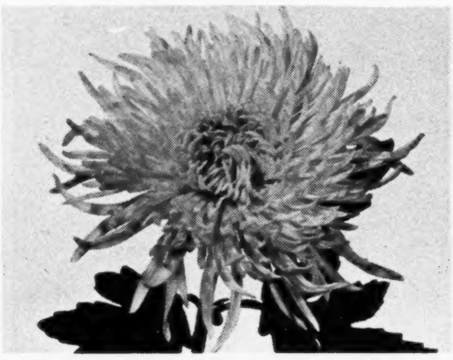
6. Feathered Decorative (BGA Golden Starburst)



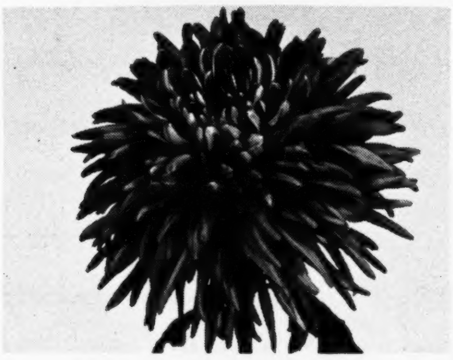
2. Incurve (GRA Improved Fred Shoesmith)



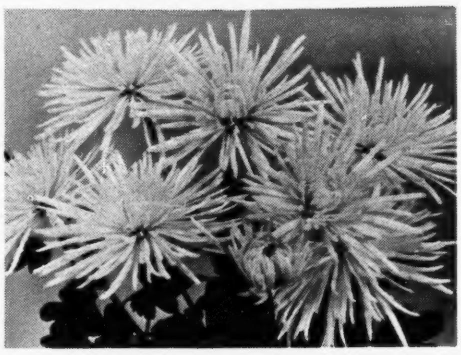
7. Anemone (BGA Nimbus)



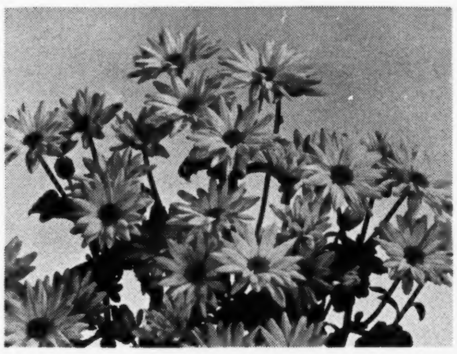
3. Spider (GRA Fuji Mefo)



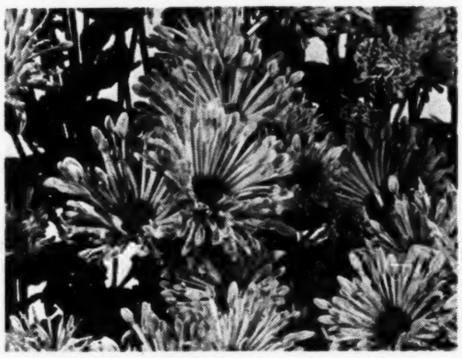
8. Reflex or Semi-Incurve (Trident)



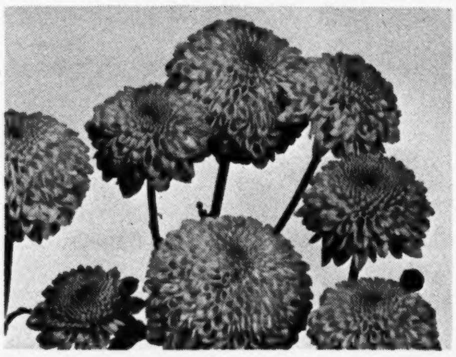
4. Fujii (Joan Ette)



9. Daisy (BGA Bright Yellow Tuneful)



5. Spoon (Shining Light)



10. Pompon (BGA Goldflo)

Figure 42. Classes of chrysanthemums. (Courtesy, Yoder Brothers, Inc., Barberton, Ohio.)

4. Fujii (straight, tubular petals, all the same length), Queen's Lace, Rayonnante, Nightingale, Joan Ette.
5. Spoon (tubular petals with flattened, broad ends), Jessamine Williams, Moonlight Spoon, Loveliness, Shining Light.
6. Feathered Decorative (irregular projections on each petal), Illini Snowdrift, Golden Starburst.
7. Anemene (short, tuft-like inner petals, broad outer petals), Daybreak, Venoya, Shane, Nimbus.
8. Reflex or Semi-Incurve (petals are broad and curve outward), Garnet King, Trident.
9. Daisy (yellow center, with broad outer petals), Valencia, Mischief, Bright Yellow Tuneful.
10. Pompon (broad petals in small, ball shaped head), Ostosa, Goldstrike, Astoria, Joybringer, Goldflo.

New cultivars are introduced each year. Current lists of them may be examined by obtaining copies of the current year's issue of commercial catalogs.

Week Group

"Week Group" is a term referring to the number of weeks from the time short days are started until the date of flowering for certain groups of chrysanthemums. The range is from 7 weeks to 15 weeks. All commercially grown chrysanthemums have been placed into these groups. Many varieties in the 9-, 10-, and 11-week groups are used for flowering all through the year. "Garden Chrysanthemums" from the 7- and 8-week groups are used for spring flowering, especially for Mother's Day and Memorial Day. Varieties in the 12-, 13-, 14-, and 15-week groups are sometimes used for fall crops, but they require more time to mature than varieties from the other groups. It is important to use those cultivars that will give good quality crops for the time of year they are to flower, with the shortest possible growing schedules.

Crop Rotations

A potted chrysanthemum crop can be produced in about 12 weeks. Allowing one week for clearing the crop and replanting, it is possible for the grower to produce about 4 successive crops of potted chrysanthemums in the same space in one year. The following example was derived from the Gloeckner 1968 Chrysanthemum Manual, Reference No. 17 , and Ball Mums, Reference No. 3 . By using tables similar to the one on the following page, it is possible to work out many different rotations. Many greenhouses use rotations to give a crop of potted chrysanthemums each week of the year (while 51 other mum crops are in various stages of development in the same greenhouses!).

Table 4. A One-Year Rotation Plan for Potted Chrysanthemums, Using 10-Week Varieties.

Plant	Light	Pinch	Shade	Flower	Clear
Feb. 22	Feb. 22 - Mar. 1	Mar. 8	Mar. 15	May 10	May 10-15
May 17	- - - - -	May 31	May 17 - July 1	July 26	July 26 - Aug. 2
Aug. 2	Aug. 2 - 9	Aug. 16	- - - - -	Oct. 18	Oct. 18 - 23
Oct. 23	Oct. 23 - 30	Nov. 6	- - - - -	Jan. 8	Jan. 8 - 13

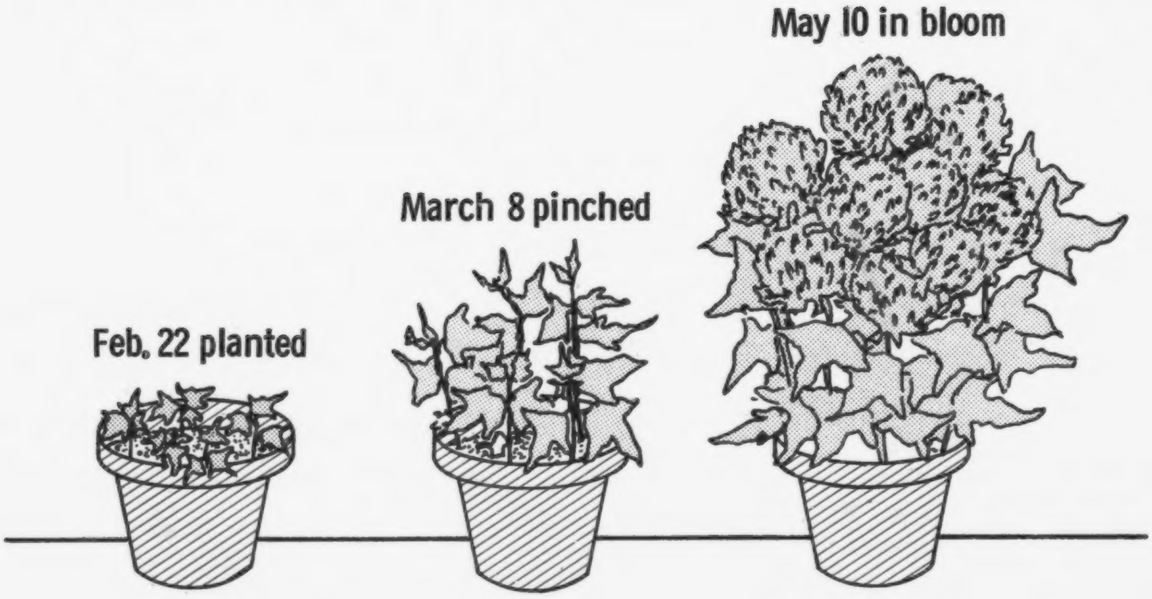


Figure 43. Development of a potted chrysanthemum planted February 22 and in bloom May 10, a 78-day schedule, using a 10-week cultivar.

Photoperiod Control

Potted chrysanthemums are usually grown vegetatively for several weeks before flower buds are induced to initiate in the upper stems. This is done so strong plants with large flowers will be produced.

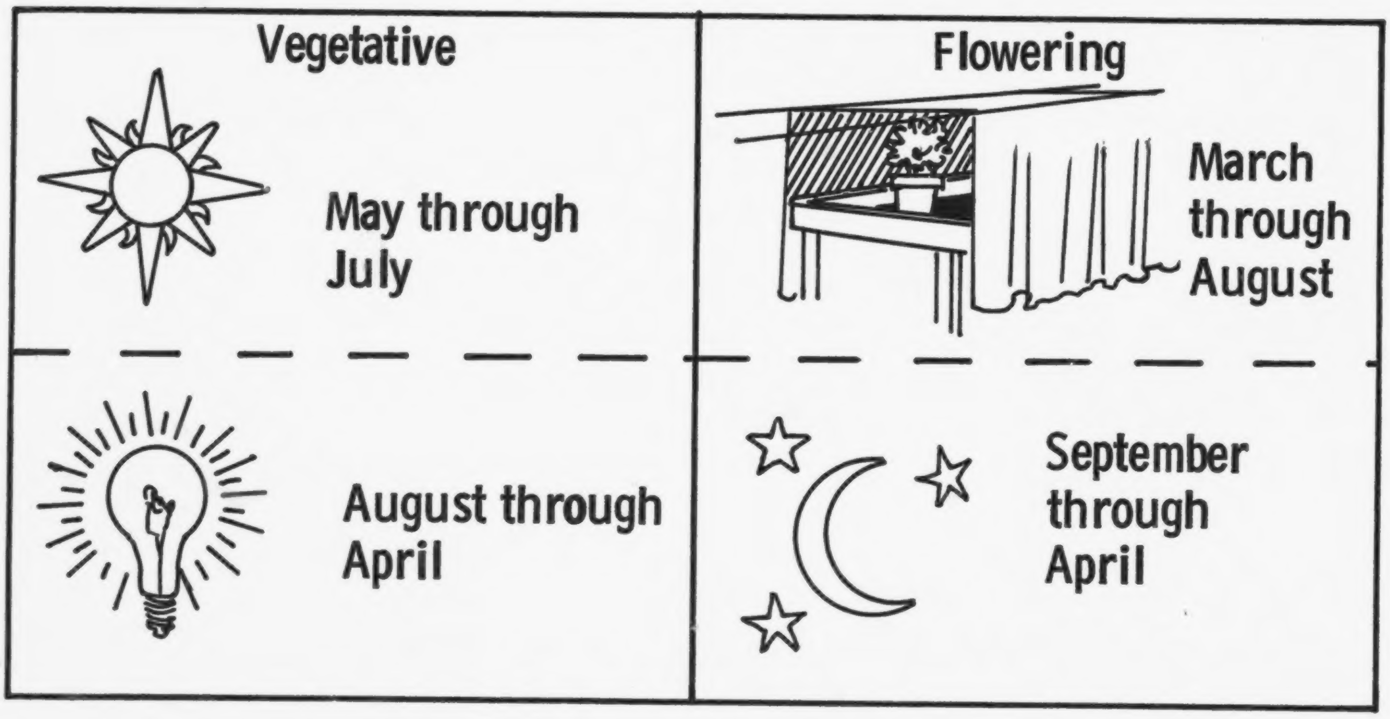


Figure 44. Controlling growth of chrysanthemums.

Vegetative (nonflowering) growth is maintained by exposing the plants to long days starting with the day they are potted and continuing for about 2 weeks. The days are naturally long enough to keep the plants vegetative from early May until late July. During the rest of the year, artificial lights are used, as discussed under "light duration" in Problem Area 2, pages 33 and 34. The lights are turned on at midnight each night. In July, August, and May, they are left on for 2 hours; in September, October, March, and April for 3 hours; and in November, December, January, and February, for 4 hours. "Cyclic" or "Flash" lighting may be used to conserve electricity (see Page 34.)

Flower buds are initiated and developed in chrysanthemums under short days. The days are naturally short enough to bring this about in the months from September to March. To provide artificially short days during the rest of the year, a special black cloth, with a tight weave, is drawn over the plants every day at 4:00 p.m. and is removed in the morning at 8:00 a.m. The number of short days needed varies from 7 to 15 weeks, depending upon the "week group" to which a variety belongs.

Propagation

Chrysanthemums are propagated by rooted stem tip cuttings. Depending on the variety used, they will easily root in 7 to 21 days. It is very important to have good quality, disease-free cuttings in sufficient quantity at the time needed. For this reason, the rooted cuttings are generally purchased from a propagation specialist.

Potting

Chrysanthemums are potted in six-inch azalea pots (3/4 pot), generally four or five rooted cuttings per pot. The rooted cuttings should be graded for size so that each pot will have uniform plants. Cuttings should be potted shallowly to insure a good soil-air-moisture relationship for rapid root growth. Planting the cuttings at an angle so that the top of the cuttings extend over the edge of the pot allows each plant more room to grow and encourages more shoots per cutting and larger and better formed plants. See Figure 45.

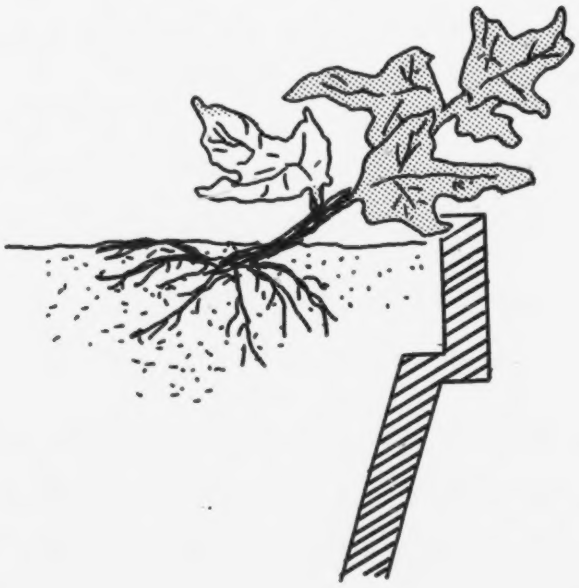


Figure 45. Rooted cuttings are potted at an angle to encourage growth of many shoots.

Chrysanthemums that have been potted into 6-inch pots are usually spaced to allow one inch between pots during the early temperature period (first 3-4 weeks). Then they are spread out so that the distance from one pot rim to another is 8 inches. Closer spacing during this time results in poorly shaped plants. Wider spacing is uneconomical.

Temperature Control

Potted chrysanthemums require different temperatures at specific stages of growth for the production of high quality plants. The following temperature periods are recommended.

Growth Periods and Temperatures for Potted Chrysanthemums

	Temperatures		
Period of Growth	Night	Dull Day	Sunny Day
First 3 weeks	65°F	65°F	75°F
First 2 weeks of short days	62-65°F	65°F	75°F
Between periods 2 & 4	60°F	60°F	70°F
Last 3-4 weeks	54-56°F	56°F	66°F

During the first 3 weeks, rapid root, leaf, and shoot growth is encouraged by the temperatures indicated. If only a section of a bench needs this treatment, a temporary tent of polyethylene draped to the floor to also enclose the heat pipes, will help. The higher humidity that develops under the tent also promotes rapid growth. On bright days, the tent may have to be opened to prevent overheating (above 85°F).

During the first 2 weeks of short days a temperature above 60°F must be maintained in order to get uniform setting of the flower buds.

After 2 weeks of short days have elapsed, a slightly lower temperature results in good growth and good development of the tiny flower buds.

Lowering the temperature during the last 3-4 weeks of the crop causes more intense color in the flowers. It also causes a "harder" type of growth which is less subject to damage when the plants are handled during transit.

Watering

Chrysanthemums must be watered immediately after planting to insure that the soil is moist and firmed around the roots. The plants must be watered heavily in the summer to keep the soil from drying in the warm temperature. Until root growth is firmly set on cuttings, misting is necessary to keep the air moist. The soil around growing plants should be allowed to dry somewhat between irrigations, but each watering must be such that the soil is thoroughly saturated.

Semiautomatic watering systems are in general use for growing potted chrysanthemums. Delivery of 1 cup of water per day per pot during spring, fall, and mid-winter is usually adequate. In summer, 2 waterings per day, at 1 cup per watering, may be needed. The amount to apply is just enough so that some excess runs from the drainage hole. The frequency of watering depends on the size of the plant, the season, and especially the variations in weather. The plants must be closely observed so they can be watered just before wilting is likely to start. However, they must not be watered so frequently that a waterlogged soil suffocates the roots.

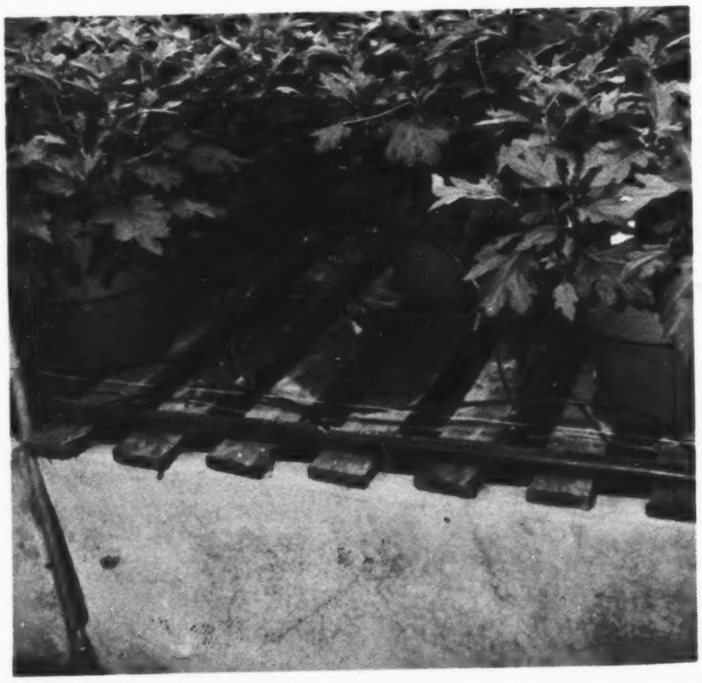


Figure 46. Semiautomatic watering for potted chrysanthemums, (Note the cone-shaped lead weight on the tube end near the center of the photograph. This weight keeps the tube in position on the soil in the pot).

Fertilizing

The soil should be tested before the plants are potted. When the soil test report is returned, instructions for adding fertilizer to the soil should be very carefully followed.

Recently, potted plant producers have been getting excellent crops by incorporating a slow-release fertilizer "Osmocote" into the potting soil at the rate of 8 oz. per bushel of soil mix after steaming. This material lasts about 3 months in the soil. Combined with "constant feed," this results in plants superior to those produced by depending wholly on Osmocote or wholly on "constant feed" to supply the nutrients needed by the plants.

Potted chrysanthemums are usually fertilized by what is called the "constant feed" method. This is done by using a very diluted fertilizer solution as the irrigation water for the plants at every watering. Many formulas are used. A popular one is a 15-10-30 fertilizer which is made up in a stock solution of 18 ounces per gallon used with a diluting device having a 1:100 dilution ratio.

Additional details on fertilizing potted chrysanthemums are given in Ball Mums, Reference No. 3 , pp. 5-8, the Gloeckner 1968 Chrysanthemum Manual, Reference No. 17 , p. 59, and Peter's Fertilizers -- Salesman's Manual, Reference No. 22 , pp. 40-41.

Pinching

"Pinching" is pruning the top 1/4 to 1/2 inch of the shoot tip by breaking it out with the fingers. This pinching causes shoots to develop from the axils of the upper leaves. From 4 to 6 branches may be produced. A plant with six pinched cuttings may have from 24 to 36 stems as a result of pinching.

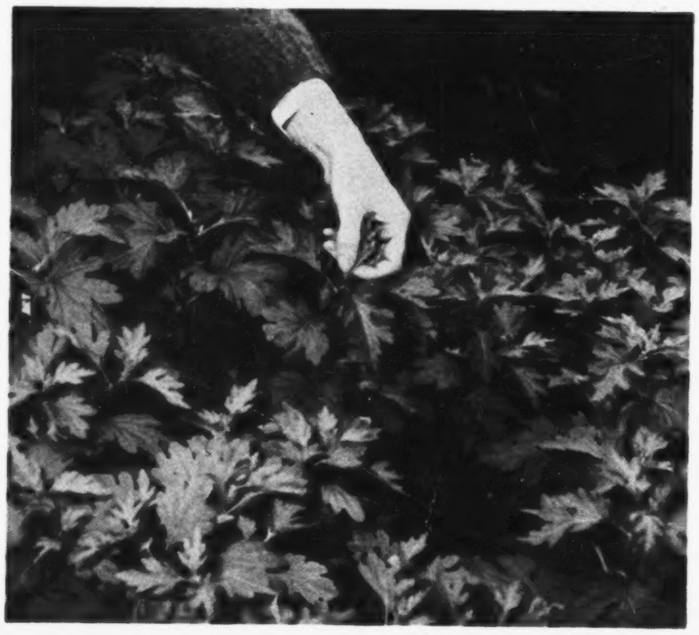


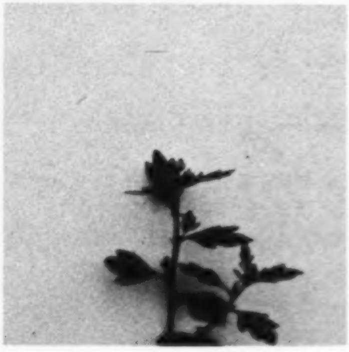
Figure 47. Chrysanthemums are pinched by removing the tip of the shoot.

Best results are obtained if the rooted cuttings are allowed to grow for about one week before pinching is done. The new shoots must be permitted to grow for about a week before short days are used to cause flower buds to form. If flower buds are started too soon, very short stems, with deformed flowers will result.

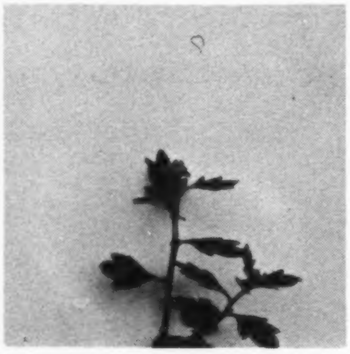
Additional details on pinching may be found in the Gloeckner 1968 Chrysanthemum Manual, Reference No. 17 , pp. 58 and 59.

Disbudding

Chrysanthemums are disbudded so that each stem produces a single large flower.



Before Disbudding



After Disbudding

Figure 48. Lateral buds are removed to leave one bud at the stem tip when chrysanthemums are disbudded.

A well grown disbudded, potted chrysanthemum will have from 24 to 36 large blooms. Shoots of chrysanthemums have one large flower bud at the end of the stem and many smaller side buds. If the side buds are not removed, a bulky-looking flower stem results. These side buds are rolled out with the fingers as shown in Figure 48. They are removed by rolling them out to one side. This is done as soon as the buds can be grasped--if they are too large when removed, the stem may be badly damaged. These buds do not all reach the same size at the same time, so disbudding usually has to be done weekly over a three week period.

Growth Regulators

Certain chrysanthemums (the Princess Anne series, for example) develop too much "stretch." They are simply a little too tall to be in good proportion with the pot. Treatment with growth regulators at the right stage(s) will shorten the stems, giving a better appearance. When side shoots are 1-1/2 to 2 inches long, the upper leaf surfaces should be sprayed once with a solution of B-Nine at 6 ounces of concentrate per gallon of water, (25% solution). The spraying should be just heavy enough so that the droplets begin to run together. A second application, two weeks later, may be desirable for very tall-growing cultivars. In summer months, the rate should be doubled to 12 ounces per gallon, (50%) for good results.

Packing and Shipping

Potted chrysanthemums are at the right stage to sell when the center of the bloom has lost most of its green color. At this point the petals will continue to open normally after the plant is sold.

The plants are usually "sleeved" as shown at the left.

Most producers sell potted chrysanthemums directly to retailers on a prearranged basis.

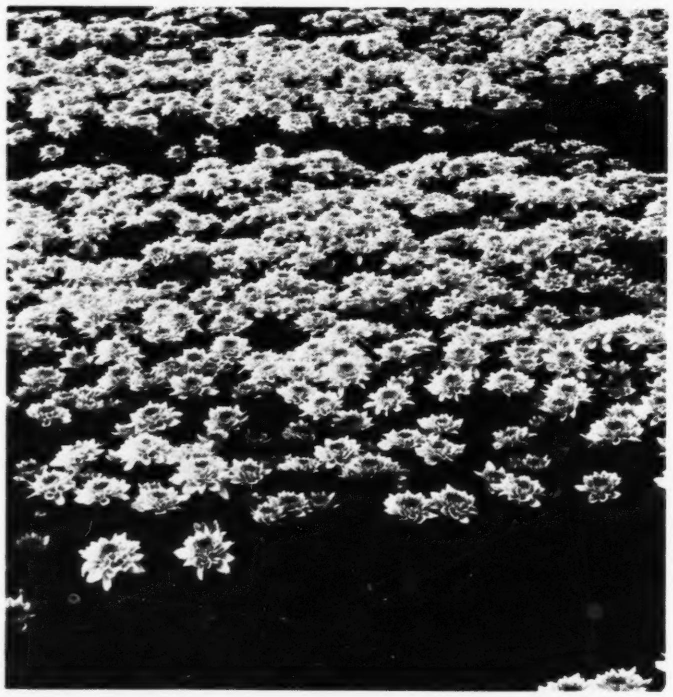
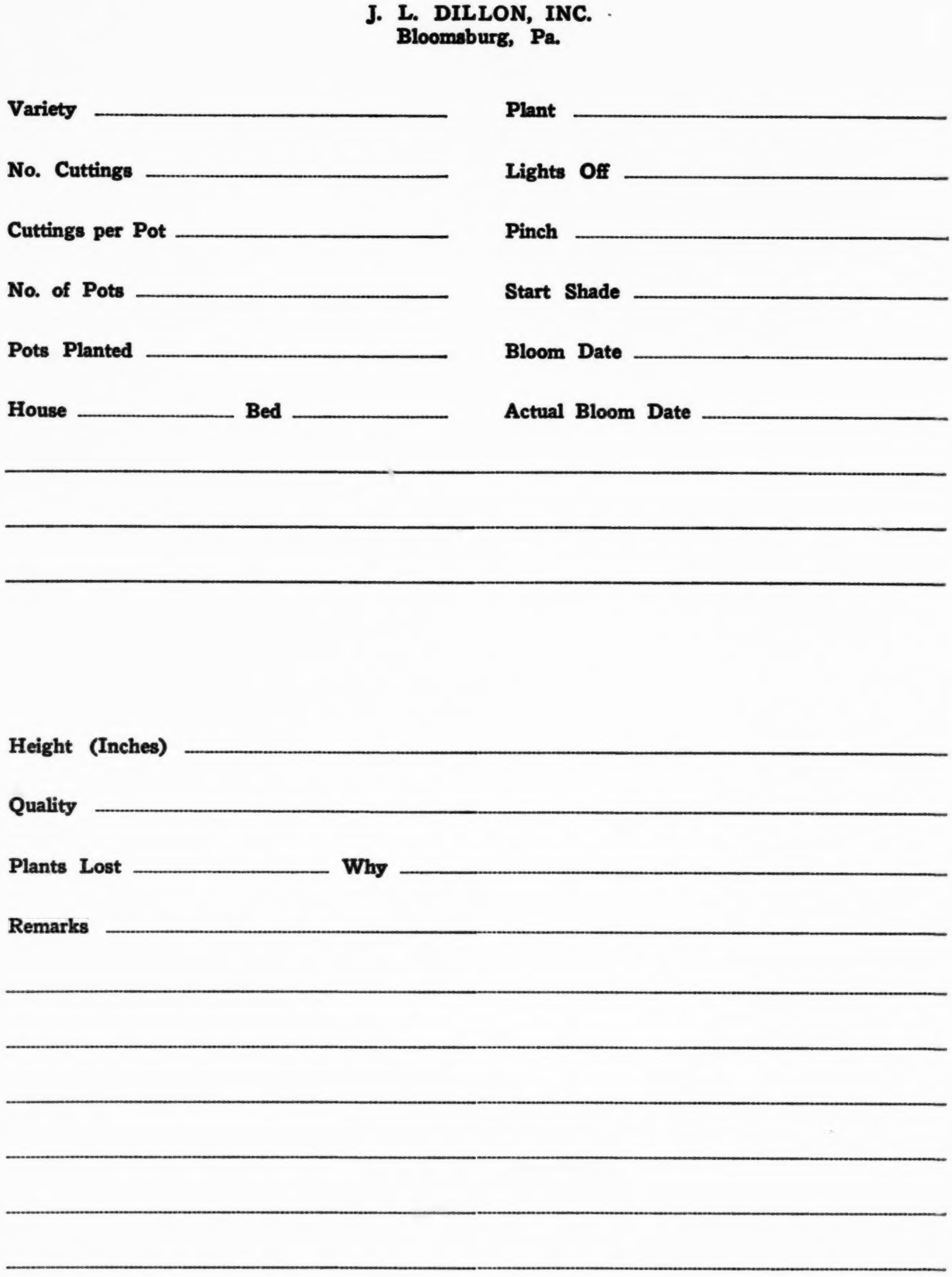


Figure 49. Prior to shipping, plants are "sleeved" in paper cones for protection (Note the stage of development).

Records

Greenhouse managers usually post record cards or record sheets on clipboards on the ends of benches at the center aisle for each bench of a potted plant crop. The record card shown on the following page is for potted chrysanthemums. The lower lines are usually used to indicate fertilizer applications and pesticide applications. Accurate, up-to-date records aid in getting tasks done on time to produce a high-quality crop.



J. L. DILLON, INC.
Bloomsburg, Pa.

Variety
Plant
No. Cuttings
Lights Off
Cuttings per Pot
Pinch
No. of Pots
Start Shade
Pots Planted
Bloom Date
House **Bed**
Actual Bloom Date

Height (Inches)
Quality
Plants Lost **Why**
Remarks

Figure 50. Front and reverse of record card for a block of potted chrysanthemums.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

References:

Ball Mums. Technical Bulletin No. 310. Reference No. 3.
The Ball Red Book. 1965. Reference No. 29.
Commercial Flower Forcing, *Seventh Edition*. Reference No. 7.
Gloeckner 1968 Chrysanthemum Manual. Reference No. 17.
Peter's Fertilizers--Salesman's Manual. Reference No. 22.
Chrysanthemums, A Manual of the Culture, Diseases, Insects and Economics of Chrysanthemums. 1964. Reference No. 6.

Supplies Needed:

- Rooted chrysanthemum cuttings
- 6-inch, three-quarters pots
- Steamed soil mixture
- Fertilizer

Suggested Learning Activities

1. Have your students work out a plan for producing a full year's crop of chrysanthemums for your locality. Be sure to allow at least a one-week clean up period between each crop.
2. Take a field trip to a greenhouse producing chrysanthemums. Note the different tasks involved.
3. If the time is right, have the students produce a crop of chrysanthemums for Mother's Day or Easter.
4. Using the table below, have your students calculate the number of 6-inch pots needed for a crop of potted chrysanthemums at a final spacing of 8 inches between pots, for a bench area of 500 sq.ft. From this figure they can calculate the number of cuttings needed. They can also calculate the amount of bench space needed for the crop during the first few weeks when the space between pots is 2 inches.

Pots per 100 square feet

		Space Between Pot Rims							
Size*	Tight	1"	2"	3"	4"	5"	6"	7"	8"
2	2500	1230	745	490	---	---	---	---	---
2¼	1900	1020	490	455	---	---	---	---	---
3	1180	710	470	340	237	---	---	---	---
4	710	470	350	260	199	137	---	---	---
5	475	340	256	200	137	130	108	92	79
6	340	256	200	158	130	108	92	79	68
7	256	200	130	130	108	92	79	68	56

*Inside diameter at the pot rim.

5. The subject of chrysanthemums, with hundreds of cultivars, presents a good opportunity to discuss inheritance in plants, especially sports and selections. Pages 78 through 81 in Commercial Flower Forcing, Seventh Edition, gives a good base for leading discussions on inheritance in plants.

Test

1. For what holiday are most chrysanthemums produced?
2. What growth habit is most desirable in chrysanthemums?
3. Define "week group."
4. What is the average time taken to produce a crop of chrysanthemums?
5. What is done to insure strong chrysanthemums with large flowers?
6. About how many cuttings are placed in a six-inch pot?
7. Why is a cooler temperature used during the last 3-4 weeks of the growing season?
8. Describe the "constant feed" method used to fertilize chrysanthemums.
9. What chemical is used to control height of chrysanthemums?

POTTED PLANTS UNIT 2

Poinsettia
(*Euphorbia pulcherrima*)

Learning Objectives

1. To learn how to select the most profitable poinsettia cultivar.
2. To learn the methods of caring for poinsettia stock plants.
3. To learn how to root poinsettia cuttings.
4. To learn how flowering of poinsettia is controlled.
5. To learn the cultural requirements of poinsettia.
6. To learn how potted poinsettias are prepared for market.

Key Questions

1. What part do stock plants play in poinsettia production?
2. Why is it necessary to control flowering with poinsettia?
3. How is temperature used to control the flowering date of poinsettia?
4. What are the fertilizer requirements of poinsettia?
5. Why is it desirable to regulate poinsettia height?

New Words

Bracts - brightly colored, leaf-like organs surrounding the true flowers of a poinsettia

Dormant - not in an active state of growth

Inflorescence - a cluster of flowers (or florets)

Medium - any substance, organic or inorganic, in which plant roots are grown, usually a mixture of soil, peat, and perlite

Peat - a soft and spongy organic compound mixed with other material to form a growing medium

Perlite - a light-weight, coarse-textured mineral compound. Used with other material to form a medium

Stock plant - a plant that is used as a source of cuttings

Transpiration - evaporation of water from the fine openings in the leaf surface

Christmas poinsettias are one of the more profitable greenhouse crops. Poinsettia production and sales have continued to increase each year in the United States during the last 30 years.

The poinsettia was first brought to this country in 1825 from Mexico by a former United States Ambassador to that country whose name was Poinsette. Hence, the name Poinsettia. The plant was grown for many years as a cut flower. This was because the only cultivars (varieties) available either shed their leaves before Christmas or did not reach maturity until after Christmas. The Oak Leaf cultivar, introduced in 1923, was the first one which possessed characteristics satisfactory for potted plants. The poinsettia has colorful bracts rather than petals, Figures 51 and 52.

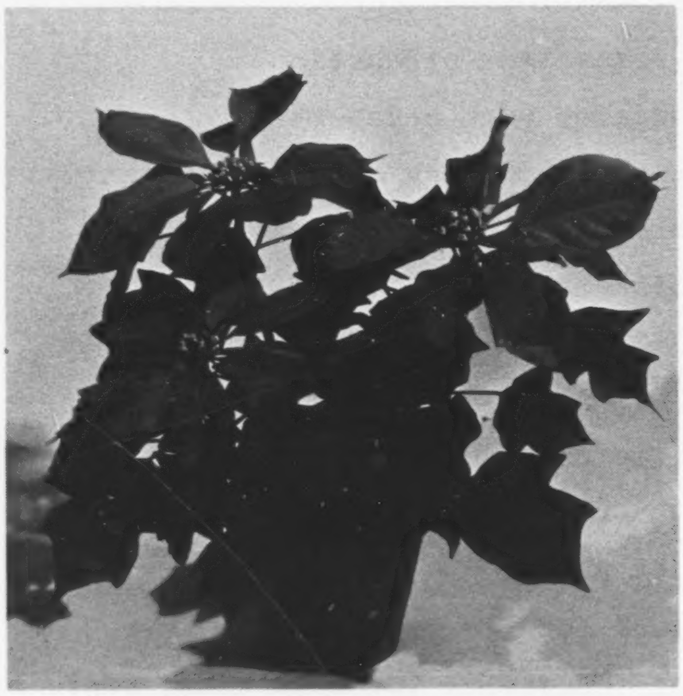


Figure 51. A potted poinsettia.

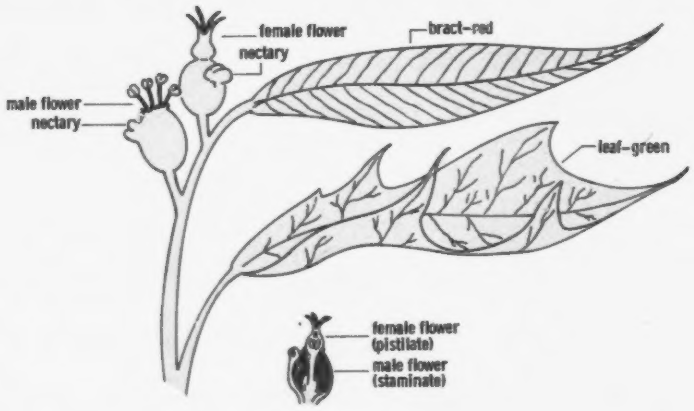


Figure 52. The parts of a poinsettia inflorescence.

The production of potted poinsettias greatly increased when it became economical to buy dormant stock plants (plants from which cuttings are later taken). These plants are produced largely in California and are shipped to all parts of the United States where they are used by growers as a source of cuttings to start a new crop each year.

Some greenhouse firms have become specialists in the propagation of poinsettias and ship rooted cuttings, or plants, in small containers to other producers of greenhouse crops who then grow these small poinsettias to salable size.

With some of the newer cultivars, instead of buying dormant stock plants, growers purchase rooted cuttings in early spring, and by encouraging rapid growth and branching, they develop plants large enough to give a large number of cuttings in early fall.

Cultivars

Choosing a poinsettia cultivar that will give greatest customer satisfaction is important.

Cultivars vary in the size of their bracts, color, height, rate of rooting, and response to pinching. The two most popular red varieties grown in the United States are Paul Mikkelsen and Barbara Ecke Supreme. Other popular varieties are the Elizabeth Ecke, Indianapolis Red, Mikkelpink, Mikkelwhite, and Ecke White.

During the past five years a great interest in improving poinsettias through breeding has resulted in the introduction and trialing of many new cultivars. Most growers of poinsettias grow small lots of new cultivars to determine how they perform.

Propagation

Stock Plants

Poinsettias are propagated from softwood cuttings. Softwood cuttings are made by removing the tip section of an actively growing shoot. This piece is usually about 3 to 4 inches long, and includes from 3 to 4 leaves.

In order to get a lot of these shoots for propagation, a grower usually purchases "stock plants," which arrive in a dormant condition in late March or early April. He starts them into growth and prunes (pinches) them to encourage the production of many new shoots for cuttings. These cuttings are usually made during the period from July to early September.

If a grower propagates his own cuttings, he usually buys new stock plants each year because it is costly to carry them over for another year.

Woody stock plants may be purchased in five different sizes. The average cost of production per cutting is about the same for each size stock plant. The five sizes of stock plants usually yield the following number of cuttings:

Size of Stock Plant	Number of Cuttings Expected
Super Jumbo	60 - 90
Jumbo	50 - 70
Grade 1	40 - 60
Grade 2	30 - 50
Grade 3	20 - 40

Northeastern poinsettia growers usually buy dormant stock plants from suppliers in California. They are shipped in late March or early April.

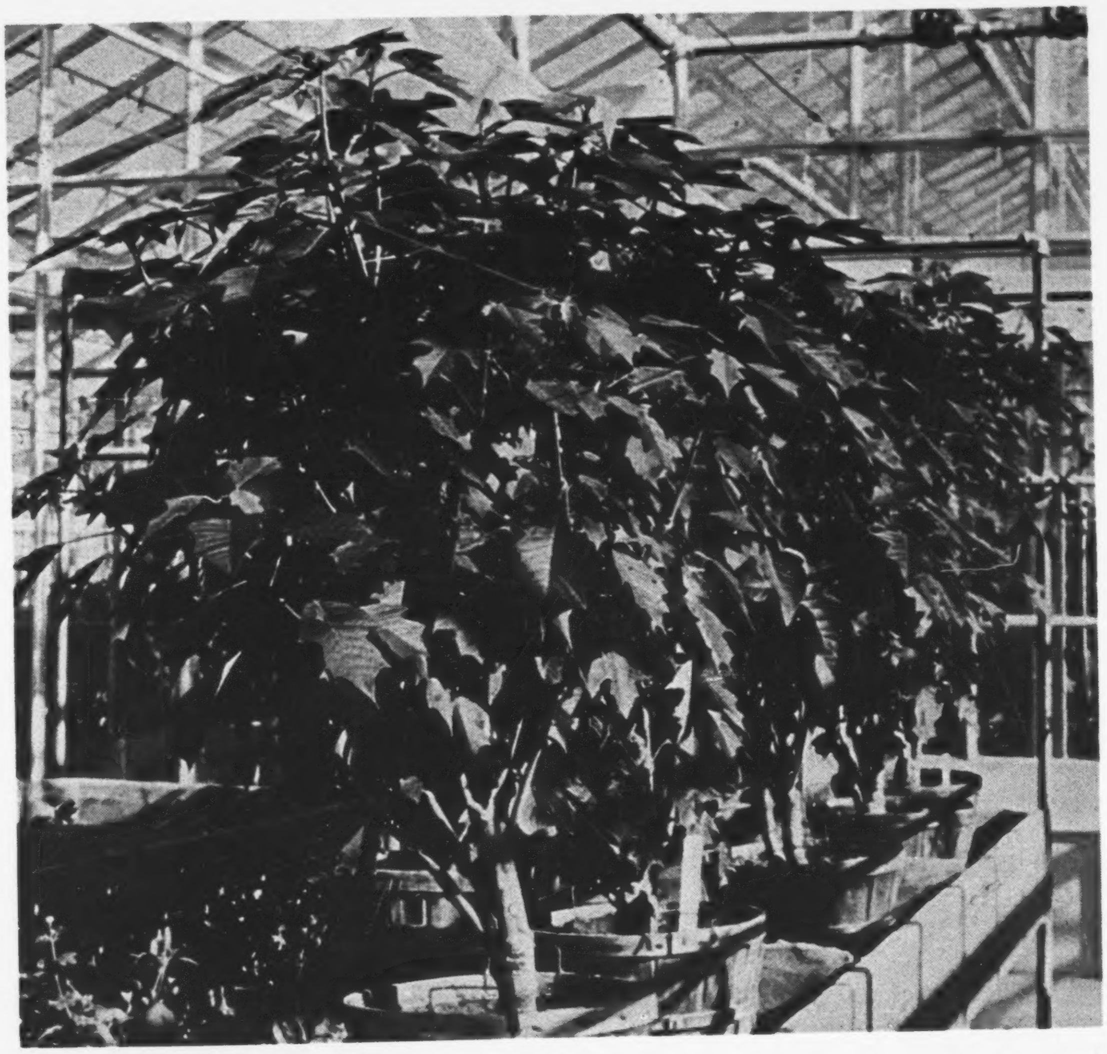


Figure 53. Stock plants may be purchased in 5 different sizes. These plants are somewhat larger than the "Jumbo" size.

Stock plants should be planted at once. If planting must be delayed, the stock plants should be stored in unopened cases at a minimum temperature of 60°F. Colder temperatures may cause injury, greatly delaying growth after stock plants are planted. Shipping cases should not be opened or the plants will dry out.

When the cases are opened, inspect the stock plants for gray mold. If gray mold is present, spray heavily with a fungicidal solution. Mix 50 percent captan wettable powder at the rate of 2 teaspoonsful per gallon of water. Spray with the solution until the plants are thoroughly covered.

Stock plants should be planted in containers which allow for good drainage. The size of the container needed will depend on the size of the stock plant used. The jumbo-size stock plant requires about a bushel of soil. Bushel baskets are often used as containers for stock plants. Plastic clothes hampers are sometimes used. Other similar containers of equal size may also be used.

Rooted cuttings, rather than woody plants, of some poinsettia cultivars may be started in 6-inch pots in March or April and grown on as stock plants by pinching them frequently and benching them at 18" x 18" in June.

The soil mixture should provide good drainage and aeration and yet have good water holding capacity. The proportions of peat and perlite in the mixture will depend on the type of soil to be used. Examples are listed below:

1. 3 parts sandy loam to 1 part peat to 1 part perlite
2. 2 parts silt loam to 1 part peat to 1 part perlite
3. 1 part clay loam to 1 part peat to 1 part perlite

Calcium and phosphorus are added to the soil prior to planting. Dolomitic limestone (which contains calcium and magnesium) should be added at the rate of 6 to 8 ounces per bushel of soil mixture. Six to eight ounces of 20 percent superphosphate should also be added to each bushel of soil.

These materials are thoroughly mixed with the soil before steaming. The mixture should then be sterilized for thirty minutes at 180°F. Some growers then mix a long acting fertilizer, such as Osmocote, at 8 ounces per bushel, with the soil before planting.

The stock plants are planted at the depth at which they originally grew.

The woody stock plants or rooted cuttings to be used as stock plants should be maintained at a temperature no lower than 65°F after planting. They grow more rapidly when the night temperature is 75°F. Spraying the dormant plants periodically with water helps maintain high humidity which encourages rapid, early growth. Once shoots start to grow this "syringing" is stopped. Plants should be in full sunlight. (Where summer night temperatures are normally near 70°F, the stock plants are sometimes moved outdoors for July and August).

Undesirable growth, such as self-branching stems or aborted flowers, should be removed. This pruning provides more space for the development of normal growth.

Stock plants should be fertilized when they have made about 3 to 6 inches of new growth. One ounce of a 20-20-20 water soluble fertilizer in 2 gallons of water should be applied at the rate of a "good watering" once each week. Observe the plants carefully for symptoms of improper fertilization and make adjustments as needed. Continuous fertilizing through the irrigation water is used in greenhouses having fertilizer injection systems.

Growers often attribute excessively soft new growth to overfertilization. It is more likely due to inadequate sunlight when the stock plants become overcrowded. It is necessary to space out the plants from time to time. The leaf tips of plants that are side by side should barely touch.

Stock plants tend to grow tall with few branches. Removing the tips of the new shoots (called pinching) produces more lateral growth. Pinching the stock plant increases the number of cuttings which may be made.

Table 5 . Time Schedule for Pinching and Taking Cuttings[1]

1st Pinch	2nd Pinch	1st Cuttings	2nd Cuttings	3rd Cuttings
May 25	June 30	August 5	September 10	October 10
June 5	July 10	August 15	September 15	- - -
June 15	July 20	August 25	September 24	- - -

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[1] James B. Shanks and Conrad B. Link. "Poinsettia Stock Plant Nutrition in Relation to Production, Rooting, and Growth of Cutting." Proc. Amer. Soc. Hort. Sci. 59:487-495, 1952.

Table 6. Poinsettia Propagation Schedule

The following table gives the appropriate handling for poinsettia cuttings taken at two-week intervals from late July until October.

Cuttings Date	Potting Date	Lighting Dates	Shading Dates	Pinch	Potting Date*	Size Pot	Number of Cuttings
Cuttings rooted in a propagation bench							
						(Azalea or "2/3" pot)	
7-21	8-15	9-25 to 10-7	- - -	8-1 (hard)	9-1	tub	7-8
8-1	8-21	9-25 to 10-7	- - -	9-1 (soft)	9-1	tub	5-6
8-15	9-7	9-25 to 10-7	- - -	- - -	10-1	9"	10-12
8-15	9-7	9-25 to 10-7	- - -	9-15 (soft)	10-1	6"	1-3
						8"	5-6
9-1	9-21	9-25 to 10-7	- - -	- - -	10-1	6"	3-4
						8"	6-7
9-15	10-7	9-25 to 10-7	- - -	- - -	direct	5"	3
						6"	3
*10-1	10-21	9-25 to 10-21	10-22 to 11-7	no	direct	3"	1
Cuttings rooted in peat or clay pots under mist							
9-1	9-21	9-15 to 10-7	- - -	do	direct	tub	6
9-15	10-7	9-15 to 10-7	10-7 to 11-1	- - -	direct	8"	5
						12"	7
*10	10-21	9-15 to 10-21	10-10 to 11-16	no	direct	6"	3
			(at 65° to finish)				

*From stock plants lighted September 25 until cuttings taken.

In southern states potting of poinsettias is usually done in late October or early November.

NOTE: "Paul Mikkelsen" should be grown at 65°F, light August 21 to September 30, and carried at 55°F after December 1.

Stock plants are usually pinched when approximately 6 to 8 inches of new growth has formed or about 2 weeks after potting in the case of rooted cuttings used as stock plants. They are pinched again after the laterals induced by the first pinchings have developed sufficient new growth. A soft pinch should be used. This means that only one half to one inch of the new shoots should be removed. Two strong leaves should remain on the branch on which the pinch was made.

Stock plants should be large enough so cuttings may be taken in August or early September. Cuttings are taken two or three times during the season. Table 6 Page 89, gives appropriate programs for different sizes of plants. They should be taken from vigorously growing shoots that are about three-eighths of an inch thick. Each cutting should be approximately 4 inches long.

Except for the last harvest of cuttings from the stock plant, at least two leaves should remain on each branch from which cuttings are removed. This practice makes possible additional regrowth from which more cuttings may be taken.

In the propagation bench, cuttings may be rooted in a mixture of either sand or perlite, or a mixture of equal parts of perlite and peat. If the cuttings are rooted in small pots, a mixture of equal parts of sand, perlite, and topsoil may be used. The rooting medium and all tools should be sterilized with steam for 30 minutes at a temperature of 180°F. Details about steam sterilization are included in Problem Area 3. Steam sterilization controls Thielaviopsis (Thie-la-vi-op-sis), a root rot disease, which cannot be controlled satisfactorily by chemical fungicides.

Rooting

Sand and perlite are coarse-textured mineral compounds. These rooting mediums contain little or no nutrients and retain only small amounts of water. Peat is an organic compound which is soft and fibrous. It has little or no nutrient value but has a high water-holding capacity. Because it is fibrous and does not pack, it helps keep the soil aerated. It is used in combination with coarse-textured rooting materials to increase the water-holding capacity of the soil medium.

The use of a root-promoting hormone results in earlier and more uniform rooting. Indolebutyric acid may be used with good results. Care should be taken to insure that the material does not "cake" on the base of the cuttings when applied. Enough hormone should be applied to lightly cover the lower one half inch of the cuttings. A bulb-type duster is satisfactory for this purpose. If any of this dust accidentally comes in contact with the stem tip, the shoot will fail to grow.

The cuttings are placed in the propagation medium about two inches deep. They are usually "stuck" about three inches apart in rows. The distance between rows is usually about 6 inches. This wide spacing is necessary because any leaves that are covered by others will turn yellow and drop off. The propagation medium should have a temperature of between 65°F and 70°F, which is often maintained by means of an electric cable in the bottom of the bench. The temperature is controlled by a thermostat. "Mist" watering is ideal for maintaining a moist medium and atmosphere. The cuttings should have as much sunlight as possible, but must never become dry due to overheating with sunlight. Roots form on the lower end of the cuttings in about 3 weeks. When the roots are about 1/2 inch long, the cuttings are at the right stage of development for potting.

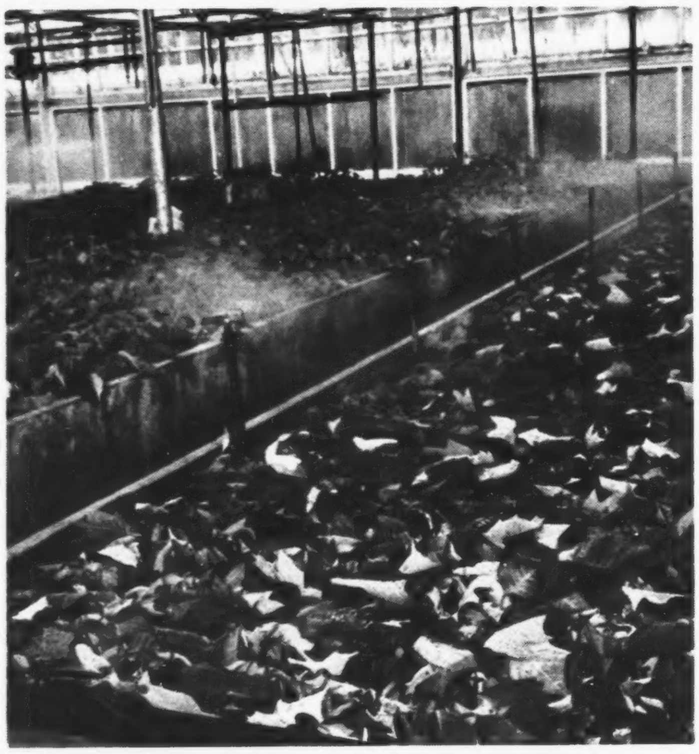

Figure 54. Poinsettias being propagated under mist.

Control of Flowering

Poinsettias are photoperiodic plants. This means that flower buds form in this plant only if the dark part of a 24-hour day is 12 hours or longer. Although stock plants or rooted cuttings are physically ready to develop flower buds in July, they do not form buds because the length of darkness during a 24-hour day in July does not equal or exceed 12 hours. In other words, the daylight period is more than 12 hours.

By September 20, the length of the dark period has become sufficiently long (12 hours) for buds to begin to develop. If the poinsettias are allowed to form buds this early, the crop will be ready to market about December 1. Obviously, this is too early for the Christmas market. Therefore, poinsettia producers use lights in their greenhouses for about one hour every night (about midnight) to prevent buds from setting. An interruption of the 12-hour dark period, even briefly, causes the plants to respond as if the night had been short.

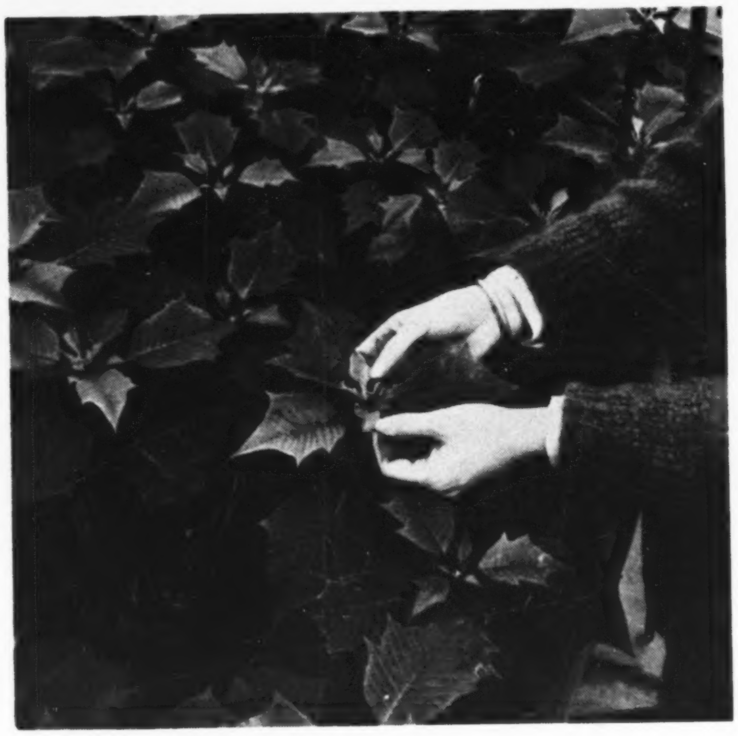

Figure 55. Buds will be clearly visible and some bracts will by colored by Thanksgiving Day.

Since most poinsettias are usually marketed after December 15, the nightly lighting should continue until about October 6. Following this schedule, buds will begin to show about October 25, some bracts will be colored by November 25, and the flowers will be open enough to sell by December 15.

After the lights are no longer used, it is essential that the daily dark period not be interrupted until at least 40 days have passed. By this time flower bud formation will have been completed. During the 40 day period, street lights near the greenhouse, automobile lights, or even a flashlight spotted on a plant may retard or prevent flower bud formation. If there is a possibility that light will affect the required 12-hour dark period, the plants should be covered with a special black cloth from 4 or 5 p.m. until 8 a.m.

Potting

Rooted poinsettia cuttings are potted in the same soil mixture as that used for the stock plants. The pot size used depends upon the time of propagation. Examination of the "Poinsettia Propagation Table," Table 6, Page 89, gives the number of cuttings and the pot size usually used for different dates.

Those planted in August or early September are usually planted in large pots and pinched to induce branching. This gives large plants for special purposes.

Probably 95% of the poinsettias grown for Christmas, however, are sold as three-flower plants in 5- or 6-inch pots. These are grown from plants propagated in early September and potted in early October.

The table also indicates how single-stem plants for sale in 3-inch pots are handled.

It also gives the program for the special case in which the grower has chosen to root the cuttings in small pots rather than in a propagation medium.

The roots of poinsettias are exceptionally brittle, and great care must be used in handling them while they are being potted. A high percentage of dead plants may be anticipated with rough handling. When the rooted cutting has been carefully inserted into the hole in the soil, the soil must be very carefully firmed around the base of the stem. Excessive pressure may actually wipe the roots off the base of the cutting.

Immediately after potting, the plants should be placed in a sunny greenhouse, and should be thoroughly watered. This watering should be repeated until water runs from the drain holes of the pots. The plants may then be watered with an automatic watering system if one has been installed. Otherwise, they are watered by hand, usually on a daily basis.

Watering

Poinsettias are watered in the same way that potted chrysanthemums are watered (see Page 77).

If they are watered by hand, water should be applied as soon as the soil feels dry to the touch. If plants show signs of wilting, the soil has dried beyond the point where watering should have been done. Young poinsettias do not use water as rapidly as older ones. In hand watering it is important to fill each pot to the rim twice. This is done by going over the plants twice. A water breaker should be used to avoid compacting the soil.

Poinsettias can be watered semiautomatically. When the time to water has been determined, the valve controlling the system is opened long enough to deliver 1 cup of water to each plant. Establish plants in a very well-drained soil may be watered once every day by a time-clock controller.

Fertilizing

Poinsettias require considerable fertilizer, but is must be available to the plants at a slow rate over the entire life of the plant.

If the soil test made of the potting soil indicates that the pH is satisfactory, the salt level is in the safe zone, and nutrients are low, a fertilizer should be added. A complete, long-acting fertilizer such as Osmocote, is usually mixed with the potting soil at the rate of 8 ounces per bushel of soil.

After poinsettias have been potted,they are then fertilized by using a dilute fertilizer solution for every watering, or they are fertilized once a week with a somewhat stronger solution (but watered with tap water in between times).

For "constant feed" (in the irrigation water) the same formulas and rates are used as for chrysanthemums (see Page 77).

If weekly fertilization is followed, each plant is given 1 cup of a solution made up of 1 ounce of a 20-20-20 fertilizer in every 2 gallons of water.

Temperature Control

Night temperatures for poinsettias should be maintained between 60°F and 62°F. Mikkelsen cultivars require a night temperature of 65°F; lower temperatures cause branching. Day temperatures may go higher but should not exceed 80°F. Temperatures below 60°F slow down growth and increase the chances of disease. Night temperatures up to 65°F may be used if the crop is late. Night temperatures should not be allowed to go above 65°F during the flower bud development stage (September 20 - October 20) because flower bud development will be retarded. Bracts will produce a brighter red color if a temperature of 55°F to 58°F is maintained during the two weeks preceding sale. Temperature changes should be no more rapid than in steps of 2°F every other night, whether raising or lowering the night temperature. Day temperature also affects the flowering date. The lower the temperature, other things being equal, the slower the flower matures. This fact is illustrated in Table 7 below:

Table 7 . The Effect of Temperature on Maturity.*

TEMPERATURES		NUMBER OF DAYS TO MATURITY
Nights	Days	
60°F	80°F	65
60°F	70°F	75
60°F	60°F	85

*Paul Ecke, Inc. The Greenhouse Culture of the Potted Poinsettia, The Christmas Plant. Paul Ecke, Inc., Encinitas, California, 1964. Ref. No. 30.

It is very important to remember that night temperatures above 65°F during the period of flower bud formation (September 20 - November 25) will delay flower bud formation. The best time to use high temperatures to speed up flowering is during the time the bracts are increasing in size -- November 25 to about December 15.

Pinching

Poinsettias are pinched to control height and to produce a branched plant with several buds. A pinch may be either hard or soft. A hard pinch removes enough new growth (about 4 inches) to provide a new cutting. The branched plant which results from hard pinching tends to grow tall and usually produces only two flowers. A soft pinch removes one-half to one inch of the terminal growth, resulting in the formation of several buds and more branching.

Hard pinches are usually made between August 1 and August 25. If the plants are lighted, hard pinches may be made as late as September 20. Hard pinching must be done at least six weeks before flower bud formation, otherwise the new growth will be insufficient to form bracts. Soft pinches may be made as late as three weeks before flower bud formation. The flower bud formation time is about October 1 for Mikkelsen cultivars and about October 7 for other cultivars.

Examples of pinching dates are given in Table 6 , "Poinsettia Propagation Schedule," page 89.

Regulating Poinsettia Growth

Poinsettias are by nature tall-growing plants. Cuttings taken in August usually become too tall for desirable Christmas plants. Several practices may be used to control plant height. Among these are: (1) giving the plants full sunlight, (2) delaying the propagation date, (3) delaying the panning date, (4) pinching, (5) restricting water, or (6) treating with a chemical growth retardant.

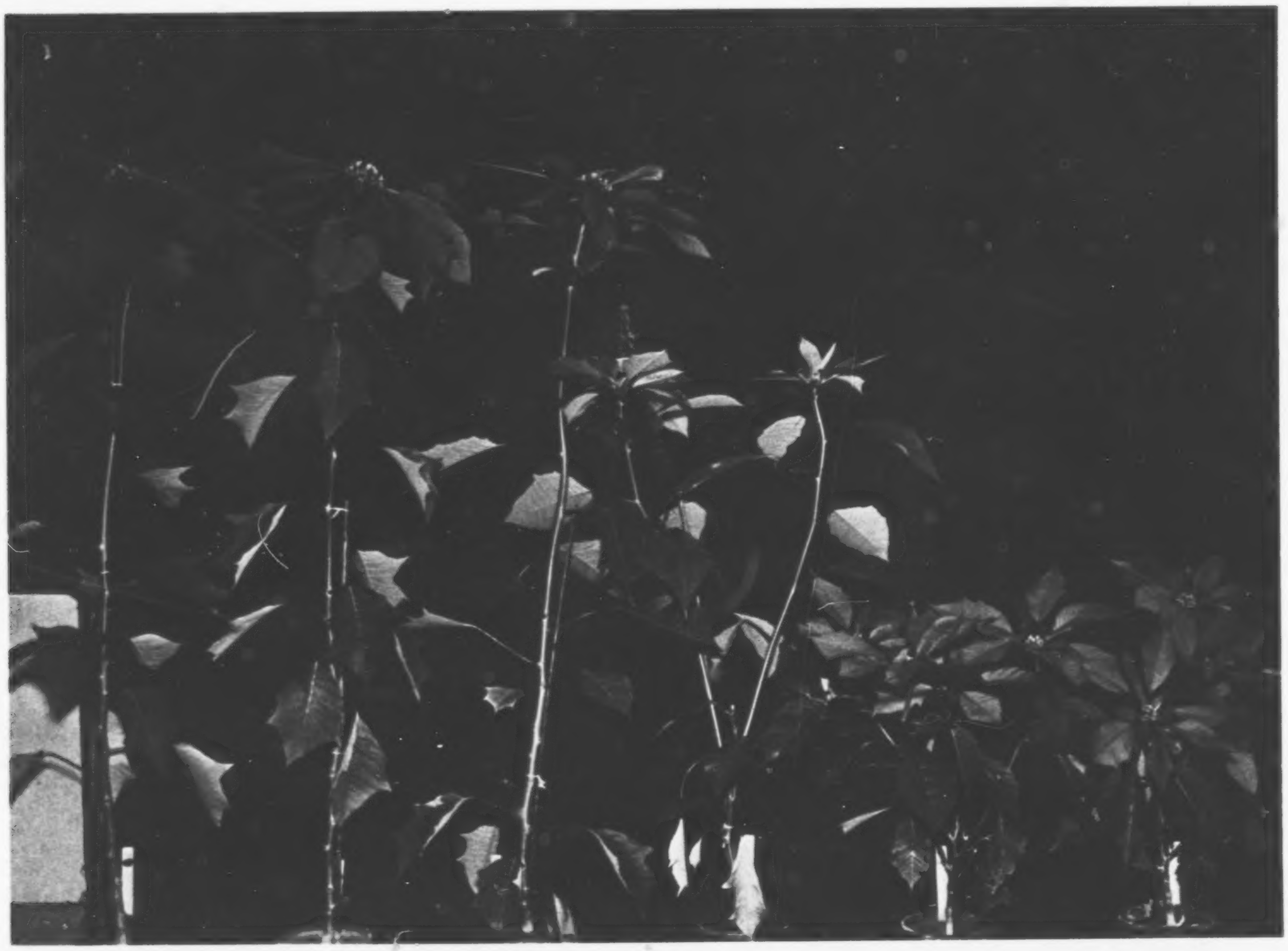

Figure 56. The four poinsettias on the left were propagated in August and were not pinched to control height. The two poinsettias on the right were pinched and formed more desirable plants.

Any one or a combination of these procedures may be used to retard growth during the season. Until the chemical growth regulator Cycocel was developed, it was customery to control height by restricting water; however, this practice often results in a loss of lower leaves and in smaller bract size. Controlling height by delaying the propagation date reduces the number of cuttings which may be harvested per stock plant. Delayed panning often results in stunting of the plant or in pot-bound root systems. Delayed pinching, which must be done six weeks in advance of flower bud formation, often results in undesirable branching of plants.

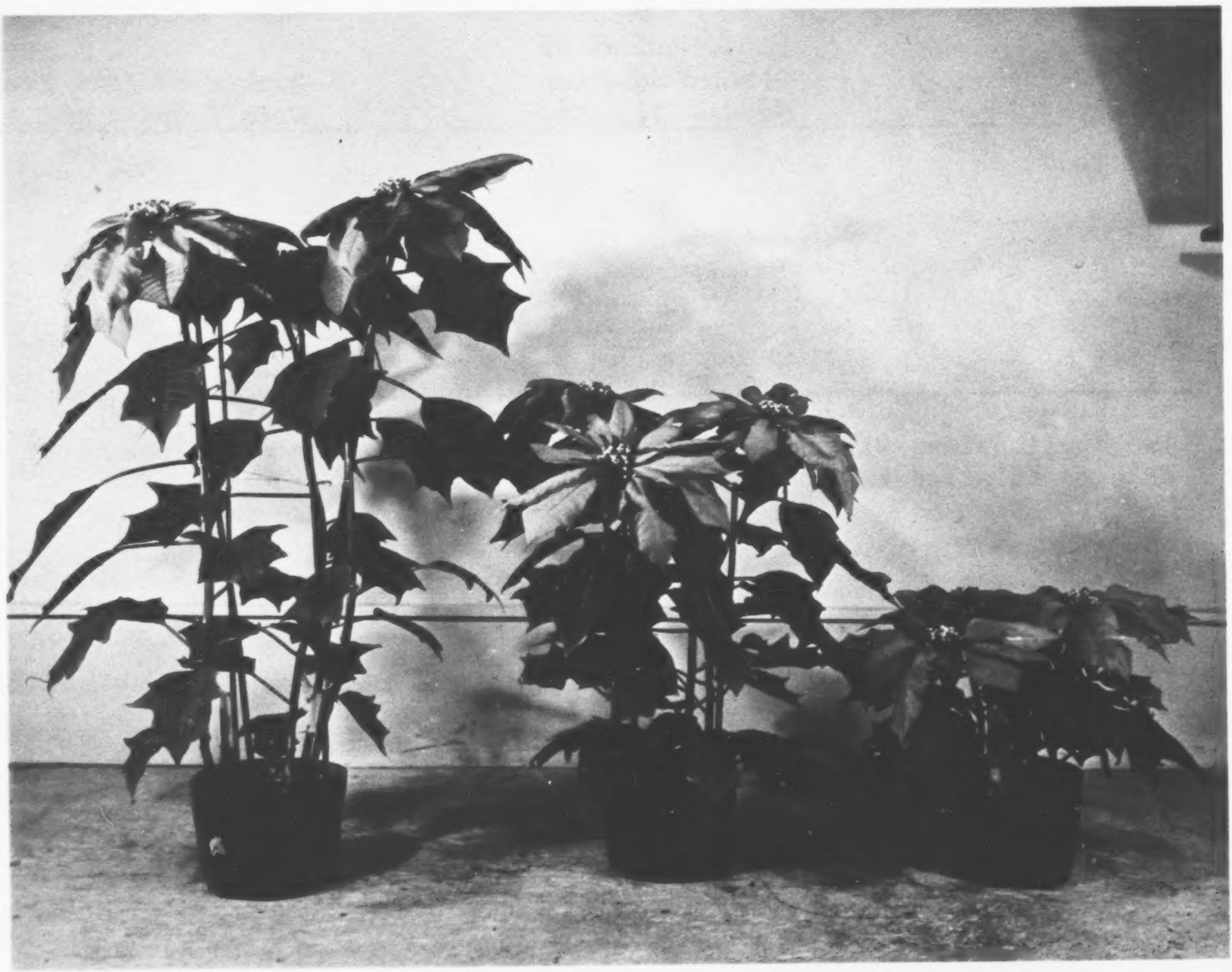

Figure 57. Chemical growth retardants used to regulate poinsettia height. The plant on the left was not treated. The plants on the right were treated with Cycocel at 2 different rates.

The use of the chemical growth retardant Cycocel is a desirable means of retarding height of plants. It results in shorter stems and darker green foliage with only a slight reduction in the size of the bracts. The material is applied as a soil drench two weeks after rooting. This is about five to six weeks after the cuttings are taken. Cycocel is available only as an 11.8 percent concentrate. It is diluted by adding one-fourth of a pint of the material in 5 quarts of water. The diluted solution is applied at the rates shown in the table below.

Table 8 . Rates of Cycocel needed for different size pans[2]

Size of Pan (Inches)	Fluid Ounces of Diluted Solution Needed Per Pan	Number of Pans Treated With 1 Quart of Cycocel
2¼ to 3*	2	640
4	3	425
5	4	300
6	6	200
8	8	150

*Two applications will be necessary to apply the recommended volume of diluted solution to 2½" pots.

Packing and Shipping

Some growers of poinsettias deliberately schedule a small part of the crop to flower two or three weeks early -- primarily for flower shops to use for advertising purposes. However, the bulk of the crop will be marketed after December 15.

The plants are graded according to size and then are grouped in uniform lots. Pots are scrubbed clean of moss. If bracts have spots of sap as a discoloration, these spots may be carefully touched up with aerosol "Christmas Red" paint in order to make the plants as attractive as possible before marketing.

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[2] D. C. Kiplinger. "Growth Regulators." Poinsettias, Agricultural Extension Service. The Ohio State University, Columbus, Ohio. Extension Bulletin S. B. 15, p. 64.

Since poinsettias are very fragile plants, special care must be provided during marketing. Wrapping flower heads individually protects them from being bruised. Wrapping the entire plant protects it from freezing temperatures which would blacken the bracts and leaves (see Figure 58 on Page 99).

A label including the cultivar of the poinsettia and directions for home care is often provided with each plant. The following directions are suggested:

1. Place the poinsettia where it can obtain sunlight.
2. Do not allow any part of the plant to touch a cold surface.
3. The best room temperature for your plant is between 65°F and 70°F.
4. Do not place the plant in a draft -- hot or cold.
5. Move the plant to a cool room at night -- but not below 50°F.
6. The plant should be watered when the surface of the soil looks and feels dry. Enough water should be added to soak the soil to the bottom of the pot.
7. If water accumulates in the receptacle under the pot after watering, it should be removed.
8. If your plant wilts or if the leaves drop, the pot should be thoroughly drenched with water. Allow the plant to drain and return it to the sunlight.

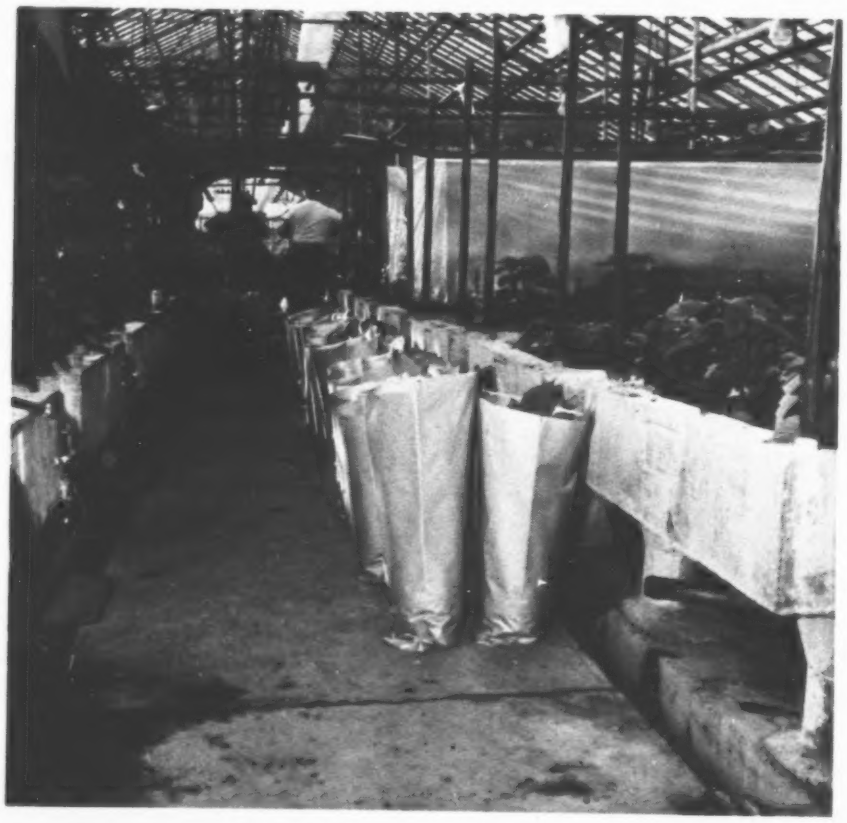
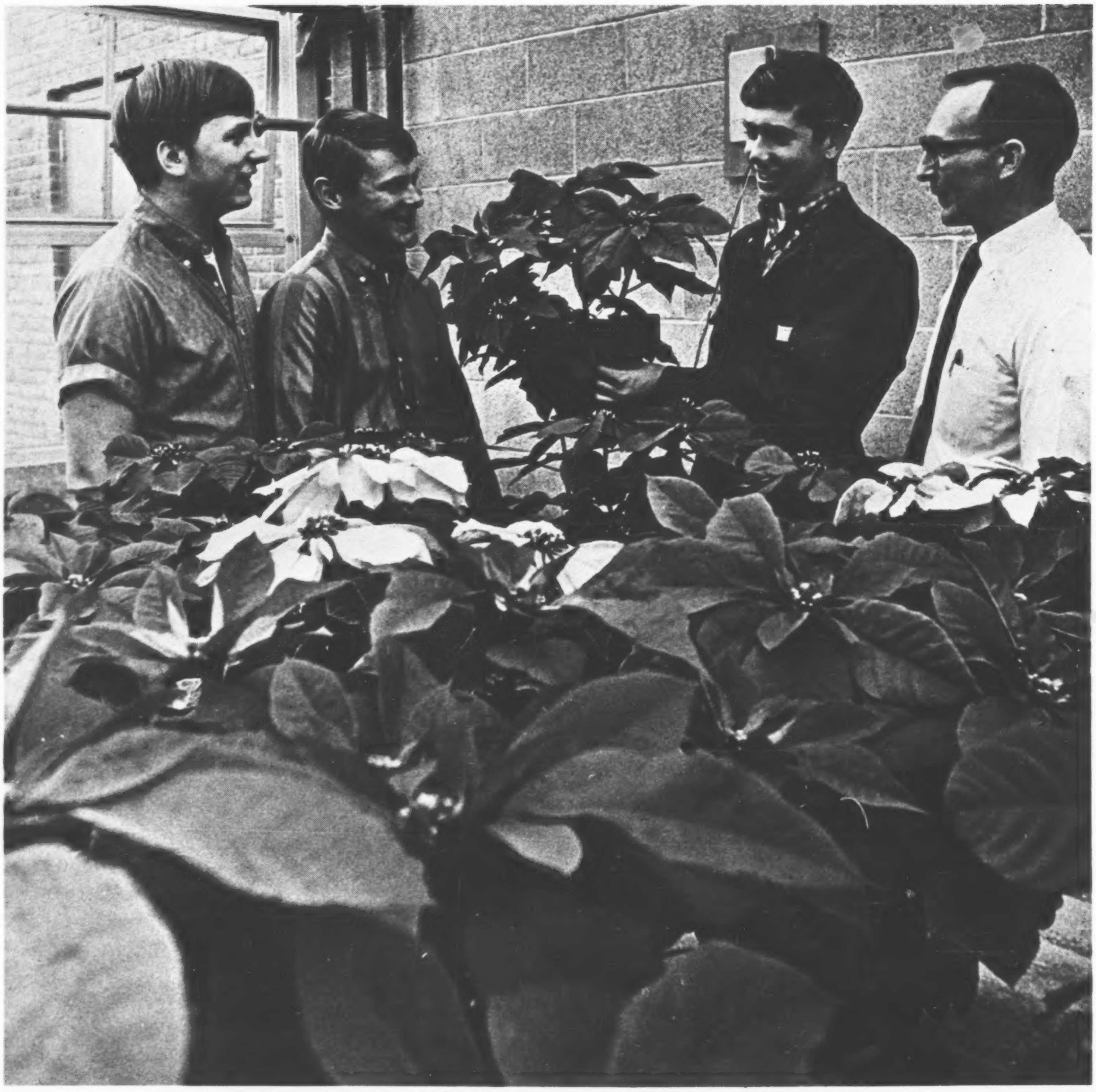


Figure 58. Poinsettias "sleeved" and ready for shipment.

Figure 59. A high school poinsettia crop.

PLANT SCIENCE PAGE
May 1969

Photo Story: Lebanon County Vo-Tech School



Lebanon County Vo-Tech School in Lebanon opened the Fall of 1968. By that Christmas the FFA Chapter had produced an excellent crop of poinsettias. Readying the plants for sale are, (left to right), Randy Kent of Northern Lebanon, Dale Brandt of Palmyra, and Ed Copenhaver of Cedar Crest. The ornamental horticulture program is under the direction of Mr. Gerald H. Seiler, vo-ag teacher and adviser to the chapter.

(Reprint from PAE, Department of Agricultural Education, The Pennsylvania State University, University Park)

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Supplies Needed for Growing Poinsettias

Supplies Needed per 100 Square Feet of Greenhouse Bench Space:

1.	Stock plants (No. 1 size - three batches of cuttings)	2
2.	Pans (6 inch pans - 3 plants per pan)	80
3.	Pots (2-1/4 or 3 inches)	240
4.	Topsoil	1 bushel
5.	Peat	1 bushel
6.	Perlite	1 bushel

Other Supplies:

1. Root promoting compound
2. Soluble 20-20-20 fertilizer
3. Dexon and terraclor
4. Insecticides
5. Cycocel

References:

The Ball Red Book. Reference No. 29.
Commercial Flower Forcing, Seventh Edition. Reference No. 7.
Flower and Plant Production. Reference No. 15.
Poinsettias, Culture and Use as Potted Plants. Reference No. 24.
The Greenhouse Culture of the Potted Poinsettia, The Christmas Plant. Reference No. 30.
The U. C. System for Producing Healthy Container-Grown Plants. Reference No. 32.

Learning Activities

1. In early September have your students work out a plan for producing a crop of poinsettias in the school greenhouse from rooted cuttings you have ordered. They should schedule dates for potting, lighting, shading, temperature changes, and fertilizing. When they pot the plants this schedule should be posted in the greenhouse with the crop as a reminder of dates for things to be done. See page 174b for suggested crop rotations for a school greenhouse.

2. Take a field trip to a commercial greenhouse in which poinsettias are being grown. Students should note the cultural practices, facilities, supplies, and types of occupations involved in growing poinsettias. Observe the special skills needed by people who grow poinsettias.
3. Ask a local greenhouse manager to come to your school and discuss the culture of poinsettias with your class.
4. Arrange for students to work at a greenhouse during the Christmas vacation period to gain experience in handling plants and cut flowers for this holiday.

Suggested Demonstrations

Number 1

Purpose: To show the effect of a root promoting compound.

Procedure: Fill ten 2-1/4 inch pots with a rooting medium. Place an untreated cutting in each of these pots. These are the experimental cuttings.

Observation: a) Compare the percentage of the experimental cuttings which root with the rooting percentage of the normal crop.

b) Compare the rate at which the experimental cuttings root with the rate of rooting for the normal crop.

Number 2

Purpose: To show the effect of a chemical growth retardant.

Procedure: In the first batch of rooted cuttings (normally treated with Cycocel) leave at least five plants untreated.

Observation: Compare the height of the untreated and treated plants.

Number 3

Purpose: To show the effect of pinching on plant growth.

Procedure: Pinch at least ten plants from the first batch about two weeks after the cuttings are rooted. Remove 1/2 to 1 inch of growth. Do not treat these plants with a growth retardant.

Observation: Compare the growth of unpinched and pinched plants.

Number 4

Purpose: To demonstrate the effect of day-length on flower bud development.

Procedure: Place a block of 12 poinsettias under long-day lighting about August 21. Remove 4 plants and place them under short-day conditions on October 10. Remove 4 more on October 20, and the last group on October 30.

Observation: Compare the flowering date of these plants with the flowering date of the normal crop.

Test

1. For what holiday are most poinsettias grown?
2. Name two popular varieties of poinsettias grown in the United States.
3. Where do most growers obtain the softwood cuttings used in propagating poinsettias?
4. What are the five sizes of poinsettia stock plants?
5. Describe a soil mixture that is desirable for poinsettia stock plants.
6. Why is a root-promoting hormone used on poinsettia cuttings at rooting time?
7. What method is usually used to control flowering of poinsettias?
8. How does one determine the pot size to use?
9. How can one tell if a poinsettia plant needs watering?
10. What analysis fertilizer is used for poinsettias?
11. Name at least three practices used to control poinsettia height.

POTTED PLANTS UNIT 3

Easter Lily
(*Lilium longiflorum*)

Learning Objectives

1. To learn the cultural requirements of Easter lilies.
2. To learn the planting schedule of Easter lilies.

Key Questions

1. Why is the scheduling of an Easter lily crop difficult?
2. How are Easter lilies planted?
3. How is fertilizing done and what kind of fertilizer is best for Easter lily?
4. What are the pests that attack this potted plant and how are they controlled?
5. At what stage are Easter lilies marketed?

New Words

Bud count - the number of flower buds per pot

Buds - part of a plant where the shoots, leaves, or flowers develop; a growing point

Bulb - an underground bud and stem covered with leafy layers with roots growing from the base

Easter lilies are grown almost exclusively as potted plants for sale at Easter. A few are also grown for cut flowers. Cut stems with several blooms are sometimes used for flower arrangements, but cut blooms are more often used singly on short stems in funeral sprays. Because the date of Easter varies from year to year within a span of four and one-half weeks, (from March 21 to April 22), timing this crop with precision is difficult. Timing is further complicated because Easter lilies that have been held in low temperature storage awaiting late planting take longer to flower than those planted for an early Easter.

Cultivars

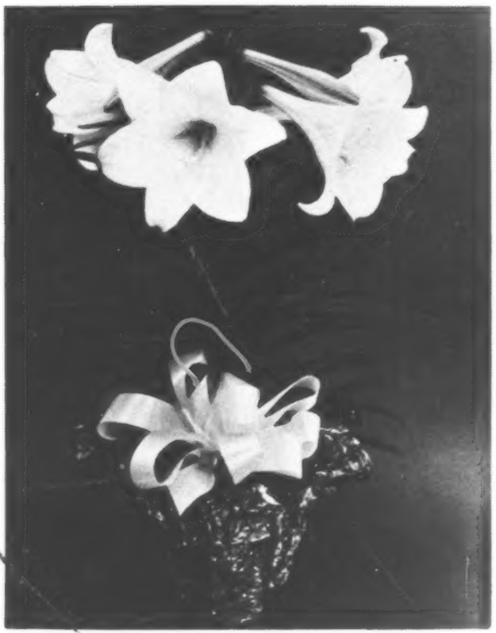


Figure 60. A well-grown "Ace" Easter lily.

The Easter lily is technically a strain of Lilium longiflorum known as giganteum. This strain originated in Japan. A number of cultivars of this strain have been introduced. The "Ace" Easter lily is one most commonly used for potted plant purposes because of its relatively high bud count, short foliage, freedom from disorders, compact growth, and large, long-lasting blooms. Other forcing cultivars include: "Nellie White," "Croft," "Estate," and "Georgia." "Croft" was used extensively until it developed a puzzling disorder called "leaf tip burn." No fully satisfactory remedy for it has been found. "Estate," and "Georgia" are used extensively in southern states where the high light intensity overcomes their tendency to be too tall. The cut flower Easter lily growers in Bermuda use "Harrisii" and "Howardi" cultivars. (Bermuda-grown cut Easter lilies often appear in eastern United States cut flower markets in spring.)

Propagation

Easter lily cultivars are propagated from scales. The scales are separated from the parent bulb and are planted during fall in beds 3 feet wide in rows about 6 inches apart. Scales are planted not more than 1-1/2 inches deep. In late fall the beds are covered with an additional inch of soil and a mulch of straw. In the first growing season, small bulbs are formed. In the second fall they are dug and replanted at a wider spacing in the field. The following fall (the third from planting) the mature bulbs are dug and graded by size in inches of circumference from the smallest size (6 1/2 to 7 inches), to the largest, (10 to 11 inches).

Easter lilies are propagated and grown to forcing sizes primarily in northern California, Oregon, Louisiana, and Georgia. On the west coast, the bulbs are dug about the first week in October. In southern fields the bulbs are harvested as early as late August. Because the bulbs continue to develop and increase in size in the fall, bulb growers do not dig them early.

Bulb Size

Most forcers of Easter lilies prefer the 8- to 9-inch bulbs because this size gives the number of flowers per plant that most customers want. The following table shows the relationship of bulb size to the number of flowers. "Double nose" bulbs, which develop two stems rather than one (but with the same total flowers), are often found in the two largest size bulbs. Table 9 also shows the number of bulbs per case of the different sizes.

Table 9. Bulb size, anticipated number of flowers per bulb, and number of bulbs per shipping case for "Ace" Easter lily.

Bulb Size (Circumference)	Flowers Anticipated	Bulbs per Case
7- to 8-inch	4	250
8- to 9-inch	5	200
9- to 10-inch	6	150
10- to 11-inch	7	100

Precooling

Precooling of lilies is the storage of the bulbs at 33° to 35°F for a minimum of 5 weeks. The precooling has the effect of bringing the bulbs into flower in less time than if they were not precooled. Most growers desire their lily bulbs with only 5 weeks of precooling for late Easters and a minimum of 6 weeks precooling for early Easters.

Some growers pot non-precooled bulbs. They accomplish the precooling effect by potting immediately upon receipt of the bulb and placing the pots in straw-covered cold frames or other places where the temperatures are between 32°F and 50°F. The advantage of early potting is to give the bulb more time to make its root system before terminal growth starts. The results are usually a higher bud count, longer basal leaves, and slightly shorter stems.

Planting

When potting lily bulbs, the soil medium should be well aerated and easily drained. The soil must also have good water-holding capacity and be provided with adequate nutrients. A good soil medium should contain equal parts of topsoil, medium grade sand, and/or other coarse material, and peat moss. The proportion of these materials depends on the texture of the topsoil used in the mixture; the coarse material should be increased for fine texture topsoil and decreased for coarse textured topsoil. The pots should be filled with the soil medium and sterilized with steam for 30 minutes at 180^{o}F.

Precooled lily bulbs should be potted immediately upon arrival. If the bulbs are left for more than 24 hours at room temperature the resulting plant may take considerably longer to force, and the bud count may be greatly reduced. About a handful of sterilized small stones is placed in the bottom of the pot to provide drainage. The soil in which the bulbs are placed should be moist and friable. About 1 inch of soil is placed on top of the small stones. The bulb is then placed, nose up, on the soil in the center of the pot. Soil is then added, smoothed even with the edge of the pot, and pressed down slightly. Lily bulbs produce roots at the bottom and above the bulb on the emerging stem. The roots growing from the stem provide the plant with an anchor to keep the plant from falling over. Because depth of planting has an effect on the number of days from planting to flowering, the bulbs should be planted at uniform depth so that the crop will flower uniformly. To make watering easy the soil surface should be one-half to three-fourths of an inch below the top of the pot after it has settled from the first watering.

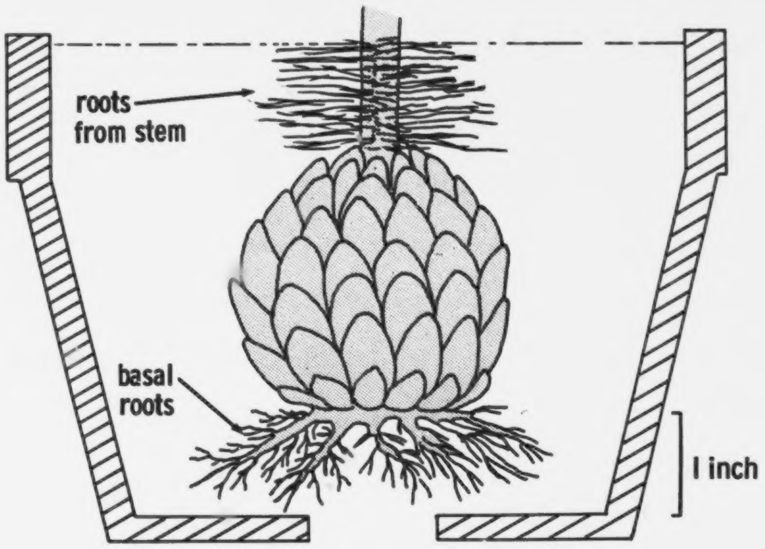


Figure 61 . Easter lily bulbs are planted 1 inch above the bottom of the pot so roots from the stem will anchor the plant.

Fertilizing

Fertilizing is done when the root system is well developed and the top growth is about 1-1/2 inches high. Most forcers use a balanced fertilizer, low in phosphate, or one containing only nitrogen, alternating between the two in their regular feeding program. A high concentration of any fertilizer will burn the roots, and weaken them. Weekly applications of fertilizer are often used. To supply the plant with nitrogen and potash a solution of one-fourth of an ounce of potassium nitrate in two gallons of water is recommended. This solution should be alternated each week with a solution of one half of an ounce of calcium nitrate in two gallons of water. This fertilizer is applied at the rate of one-half pint per six-inch pot. This is continued until the flowers are one-half inch long. If "constant feed" is used, a 16-4-12 formula is recommended, at a 200 ppm Nitrate, see Table 3 on page 51.

Watering

Lilies should be watered thoroughly at the time of potting so that some water runs from the drain holes. They are not watered again until the soil is dry to the touch, usually 3 to 5 days. They are watered only when necessary, but when watering is done, they should be watered completely.

To have a good root development the soil should not be heavy or waterlogged. It should not be so dry as to cause wilting. The soil should be kept moist all the time.

High soluble fertilizer salts in the soil may occur if the soil is poorly drained. This condition may also result from inadequate watering. Enough water should be applied to wash out some of the fertilizer salts each time the plant is watered. A plant which wilts or has a yellowish color even though the soil medium is damp, may be showing symptoms of soluble salt build-up. This condition is not likely to occur if watering is done correctly and if drainage is good.

Timing

Approximately 115 days is required from the time of potting to flowering if "Ace" lily bulbs are forced at 60°F night temperatures. With higher temperatures less time is needed and with lower temperatures more time is needed.

Table 10, "Easter Lily Schedule - 1970" on page 108 gives the stages of development for each week during the forcing program. Very often about 3/4 of a crop will conform with the schedule (if planted on time) while about 1/4 will include plants that are behind as well as plants ahead of schedule. The first stage at which this can be seen is when the shoots begin to break the soil surface. During that week, the bulbs that have no shoots breaking the soil surface should be moved to a 65°F greenhouse. Those that are 1 to 2 inches high (while most are just breaking the surface) are ahead of schedule and should be moved to a 55°F greenhouse. Two weeks later, the plants that were taken from the 60°F greenhouse because they were ahead or behind the forcing schedule are returned to it if they are at the right stage of development. In a similar manner, every 2 weeks the plants are individually examined to see whether they need to be speeded with higher temperature or slowed with lower temperature. An Easter lily crop, or part of one, that is 2 weeks off the forcing schedule at the beginning can be flowered on time if the grower carefully adjusts the temperature to control the speed of development of the plants. The reason the crop is not simply started late and run at high temperatures, which would give a shorter forcing schedule, is that an Easter lily crop grown continuously at high temperatures would have long, weak stems, poor foliage color, and small blooms. Continuous low temperatures give excellent quality, with more flowers, but takes so long that the greenhouse space is not economically used.

Light intensity is not important during the two to three weeks that the roots are developing before the shoot begins to appear. Once shoots appear, the plants must have full sunlight.

Lily bulbs for late Easter, in late April, are potted from mid-December to immediately after Christmas and placed on benches vacated by poinsettias. They may be stacked as shown in Figure 62 during the rooting period, in order to save space. At the first sign of shoot development, however, the plants must be given full light.

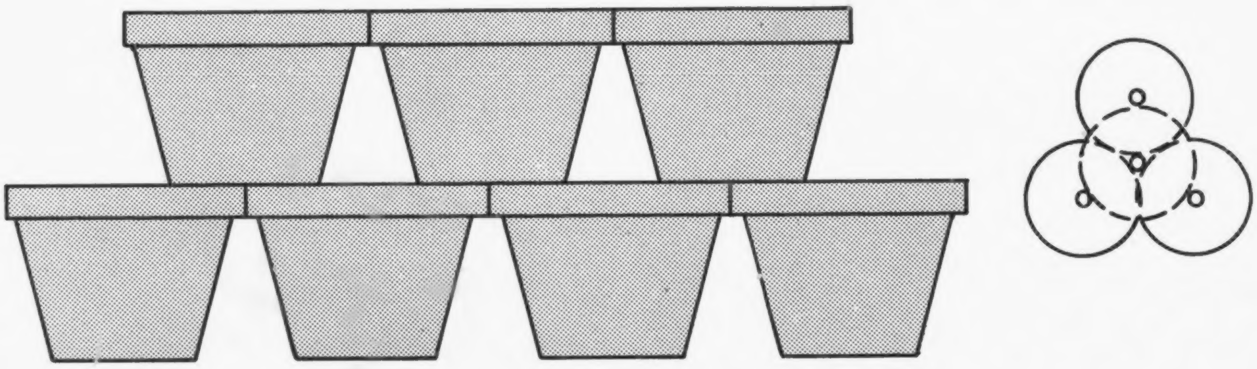


Figure 62. How pots of lilies may be stacked during the rooting period (2 to 3 weeks) to save space. Note that drainage holes are directly over open spaces between lower pots.

Several plant scientists are developing more precise cold storage and forcing techniques that promise to result in more compact Easter lilies, with more flowers, with shorter schedules.

Table 10. Easter Lily Schedule - 1970*

Date**	Days Between Dates	Development
Dec. 1 - Dec. 15		plant, water, 50, 55°F., light or dark
Dec. 23		roots at soil ball
	7	
Dec. 30		60°F, tops breaking soil surface
	7	
Jan. 6		top growth 2-3"
	7	
Jan. 13		top growth 4-6"
	7	
Jan. 20		top growth 6-8"
	7	
Jan. 27		top growth 10-12"
	7	
Feb. 3		top growth 15", start photoperiod treatment if needed***
	7	
Feb. 10		buds can be felt
	7	
Feb. 17		buds visible
	14	
March 3		buds 2-3" long and bending down, end photoperiod treatment if used
	7	
March 10		buds 3-5" long
	7	
March 17		Buds fully developed, 50°F
	7	
March 24		buds whitening
	3	
March 27		buds opening
	2	
March 29		Easter

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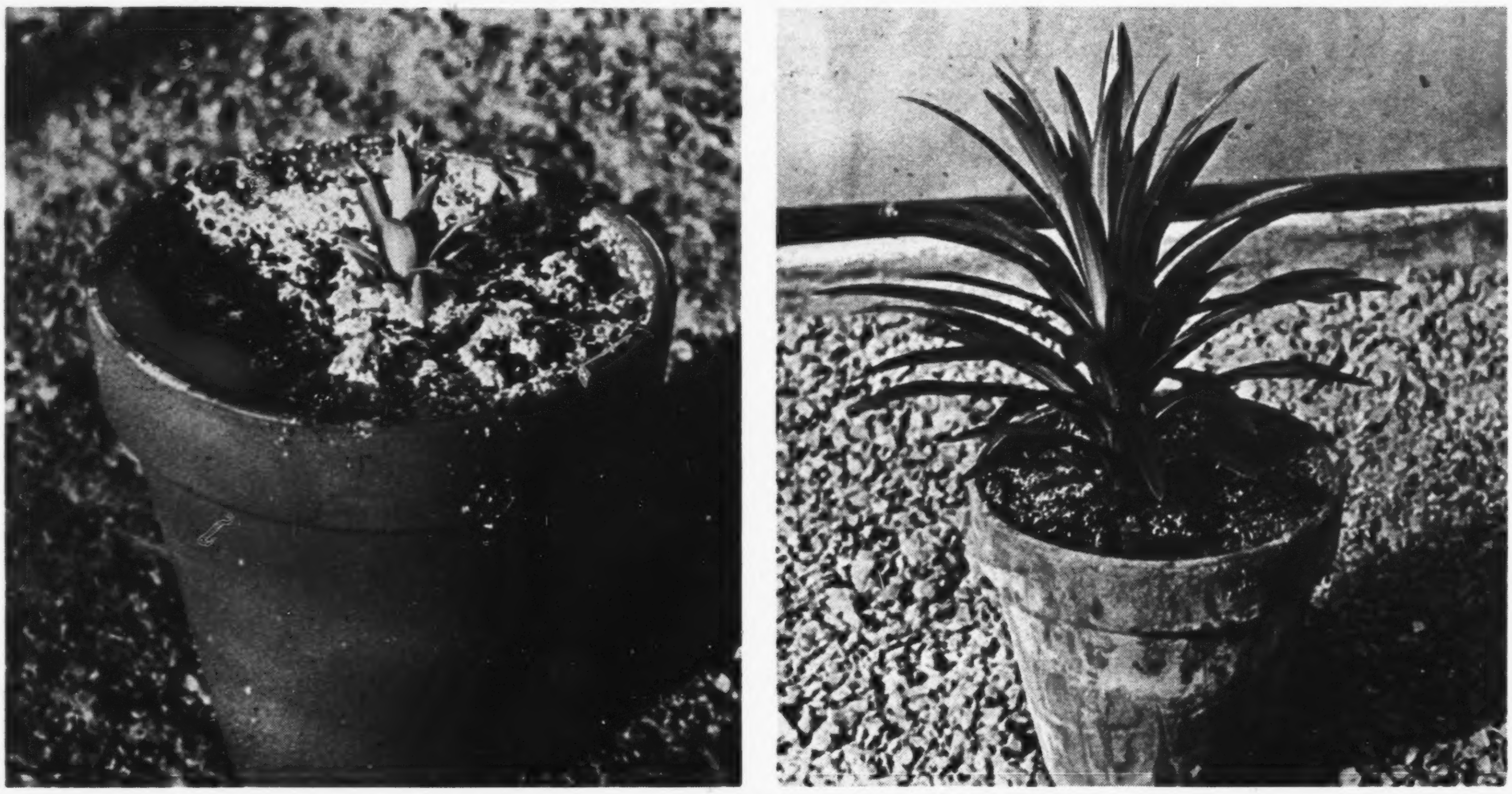
*115 days for "Ace" lily.

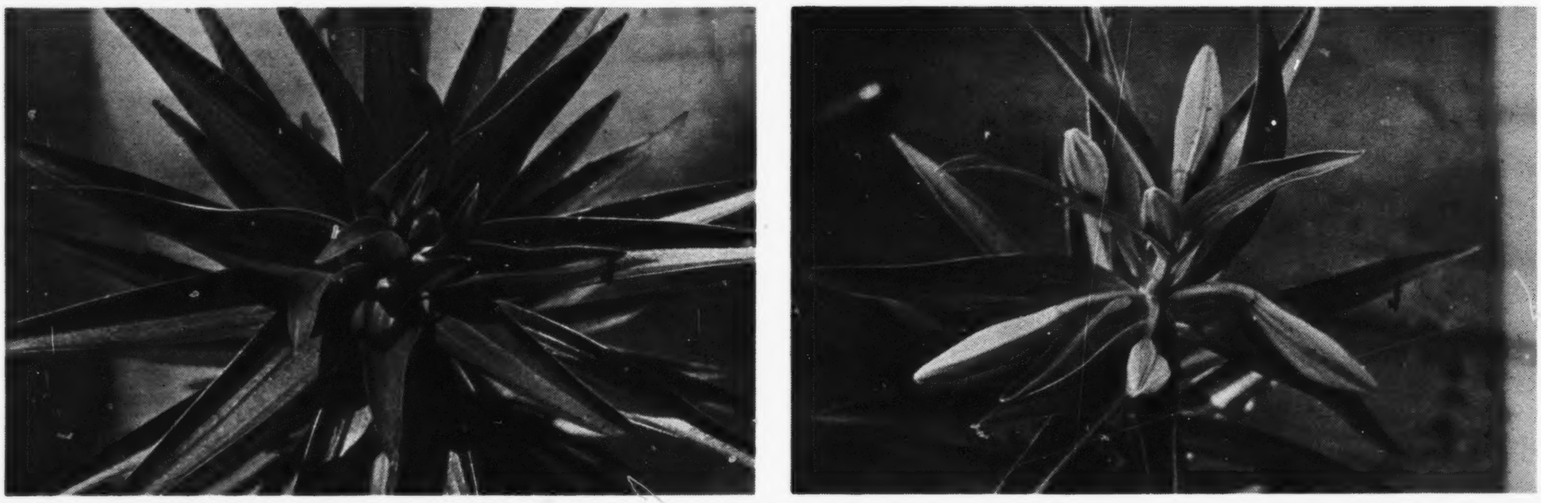
**Adjust backward or forward for Easter of other years, see Appendices A and B.

***photoperiod treatment: to reduce height, give 8-hour days; to increase height, give 16-hour days.



January 6, 1970 — 2-3" of top growth

January 27, 1970 — 10-12" of top growth



February 17, 1970 — flower buds visible

March 3, 1970 — buds 2-3" long and bending down

Figure 63. Four developmental stages for "Ace" Easter lily being grown for sale for Easter, March 29, 1970.

Straight Stems

Easter lilies will not develop straight stems under greenhouse conditions, but lean at an angle toward the south because they receive the greatest amount of light from that direction. A leaning lily is not acceptable to most customers. Lily growers overcome this problem by giving each pot a 1/4 turn once a week. This results in straight stems.

Height Control

An odd thing about Easter lilies is that bulbs from the same case may perform differently in one greenhouse than in another. In one they may grow too tall (over 18", pot included), while in another, too short (under 12", pot included). Unfortunately it is not possible to predict the height of these plants early enough in the forcing period to do anything about controlling it. After one or two seasons, however, a grower can anticipate whether his lilies are likely to be just right, too tall, or too short. He can then control the height by controlling the photoperiod. The photoperiod treatment is most effectively applied in the middle weeks of the forcing time, starting at the beginning of the 7th week after potting and continuing for about 3 weeks (until the flower buds change position from vertical to horizontal). If the grower wants to keep his lilies from becoming too tall, black cloth is used (just as for chrysanthemums) to provide an 8-hour day. If the grower wants to make his lilies taller than they have been in previous crops, he uses lights at night (just as for chrysanthemums) to extend the day length to 16 hours.

Table 10, "Easter Lily Forcing Schedule - 1970," gives the time for the photoperiod treatment to start and end. Figure 63 gives four developmental stages for this schedule.

Pests

The most troublesome pests of Easter lilies are aphids and root rot diseases.

Aphids are green, soft-bodied insects about 1/4 inch in diameter. They are sometimes called plant lice. They are mainly found on the leaves at the stem tip. They may cause a separation of the petals in the flower. This is called "splitting" in Easter lilies. These pests also make the plants unsightly with their cast-off skins. Aphids are sometimes accidentally shipped with the bulbs after they have burrowed down between the scales just before the bulbs are dug in the fields.

Spray materials that are recommended for the control of aphids on Easter lily include: Endosulfan 50% WP, _or_ Lindane 25% WP, _or_ malathion 25% WP, _or_ parathion 15% WP, at the rate of 1 lb. of material per 100 gallons of water. Diazinon 50% WP at 1 lb. per 100 gallons of water may cause injury to certain cultivars. Aerosols that can be used include: endosulfan, lindane, malathion, parathion _or_ sulfotepp. Smoke bombs of nicoture sulfate _or_ sulfotepp are effective.

Root rot is sometimes a serious problem in Easter lilies, particularly if the soil is not well-drained. Using steamed potting soil is an essential preventative control for this problem. This disease causes a lily to suddenly stop growing, and the top may wilt easily and the lower leaves may start to turn yellow. Examination of the roots shows that they are black instead of light brown with white tips. At the first sign of root rot in a lily crop the entire crop should receive a soil drench with Dexon-Terrachlor, applied according to the directions on the container.

Packing and Shipping

Cut lilies are harvested 1 day before the first flower opens. The flowers open in the wholesale house or retailstore.

Pot lilies are ready for sale when the first flower is fully open. To hold the buds and foliage in good condition for as long as 2 weeks, the plant should be placed in a dark 40°F room one day before the first bud would open. The anthers should be removed because they produce pollen which stains the flower.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Supplies:

Easter lily bulbs

Pots

Sterilized soil mixture of topsoil and sand

Peat moss

Commercial catalogs

References:

The Ball Red Book. Reference No. 29

Commercial Flower Forcing - Seventh Edition, Reference No. 7

Easter Lilies-The Culture, Diseases, Insects and Economics of Easter Lilies. Reference No. 12

Flower and Plant Production. Reference No. 15

Audio-Visual Aids:

None

Learning Activities

1. Have students visit a greenhouse where potted Easter lilies are grown.
2. Have students plan for an Easter lily crop in the school greenhouse. They should calculate the number of bulbs and pots needed with a 2-inch spacing between pots (see the table on page 82a) and derive an Easter lily forcing schedule from the one given on page 108 and "Flower Holidays 1970-1976," Appendix B. This schedule should be posted in the greenhouse with the crop so it can be referred to frequently.
3. Arrange for students to plant and grow an Easter lily crop.
4. At this point, students may be ready to study floral parts. An Easter lily flower is relatively simple and the parts are large enough to be easily distinguished. By sectioning the ovulary it is possible to see the ovules with the unaided eye. (Note, technically a lily, like the tulip has three sepals and three petals which are fused to form the corolla). Pages 67-70 in Commercial Flower Forcing - Seventh Edition are helpful. Additional flowers that should be studied structurally are poinsettias, snapdragons, chrysanthemums, roses, and carnations.

Suggested Placement Experience

1. Have the student serve as an apprentice to a greenhouse where lilies are being planted.
2. Have the student identify some of the pests seen attacking the plants.

Test

1. When is an Easter lily planted so that it will be in full bloom on Easter day?
2. Name some varieties of Easter lily.
3. What is the advantage of precooling lily bulbs?
4. What kind of soil is best for the culture of lilies?
5. Why should the soil be sterilized before planting the bulb?
6. Why is uniform potting depth important for an Easter lily crop?
7. What size bulb do most forcers of Easter lily prefer to plant?
8. Why is deep potting of Easter lily bulbs necessary?
9. How is nitrogen and potash supplied to the plants?
10. What should be done to prevent leaning lilies?
11. Explain how to control the height of Easter lily.
12. Name the two most serious pests of Easter lily.

POTTED PLANTS UNIT 4

Bedding Plants

Learning Objectives

1. To become familiar with propagation schedules for bedding plants.
2. To learn the techniques of propagation from seeds and cuttings.
3. To learn how to grow bedding plants.
4. To become familiar with the marketing of bedding plants.
5. To learn how bedding plants are used.

Key Questions

1. Why is the term bedding plants outdated?
2. What would the propagation schedules be for your area for the most popular bedding plants?
3. What is the marketing date for bedding plants in your area?
4. What would be a desirable soil medium for bedding plants?
5. How are seed flats sown and cared for until germination?
6. What is the proper fertilizing method for seedlings?
7. How should seedlings be transplanted?
8. What is the reason for using growth-regulating chemicals?
9. What is the preferable method of marketing bedding plants?

New Words

Annual - a plant that completes its life cycle from seed, through growing, flowering, to seed again in one season

Bedding plants - partially grown flowering plants and vegetable plants sold for use around homes and parks and other outdoor plantings

Calcined clay (Turface, Tena-Green, Arcillite) - montmorillonite clay (a specific type) which is baked at a high temperature then pulverized to small granular size. It retains large quantities of water, but also provides good aeration when used in soil mixtures.

Damping off - a fungus disease that kills seedlings

Dibble Board - wooden or plastic sticks 3 to 4 inches in length, tapered at one end and attached to a flat board. It is used to make many planting holes in soil at one time.

Flat - a shallow wooden tray

Shock - an interruption in growth due to a disturbance

Vermiculite - mica which was heated to 1400°F. It is sterile as it exists in the bag. It has a plate-like structure that enables it to retain both water and fertilizer. It is added to soil to improve aeration and water holding capacity.

The term "bedding plants" originally referred to plants grown for elaborately designed flower beds that were planted each spring around private homes and in public parks in the early 1900's.

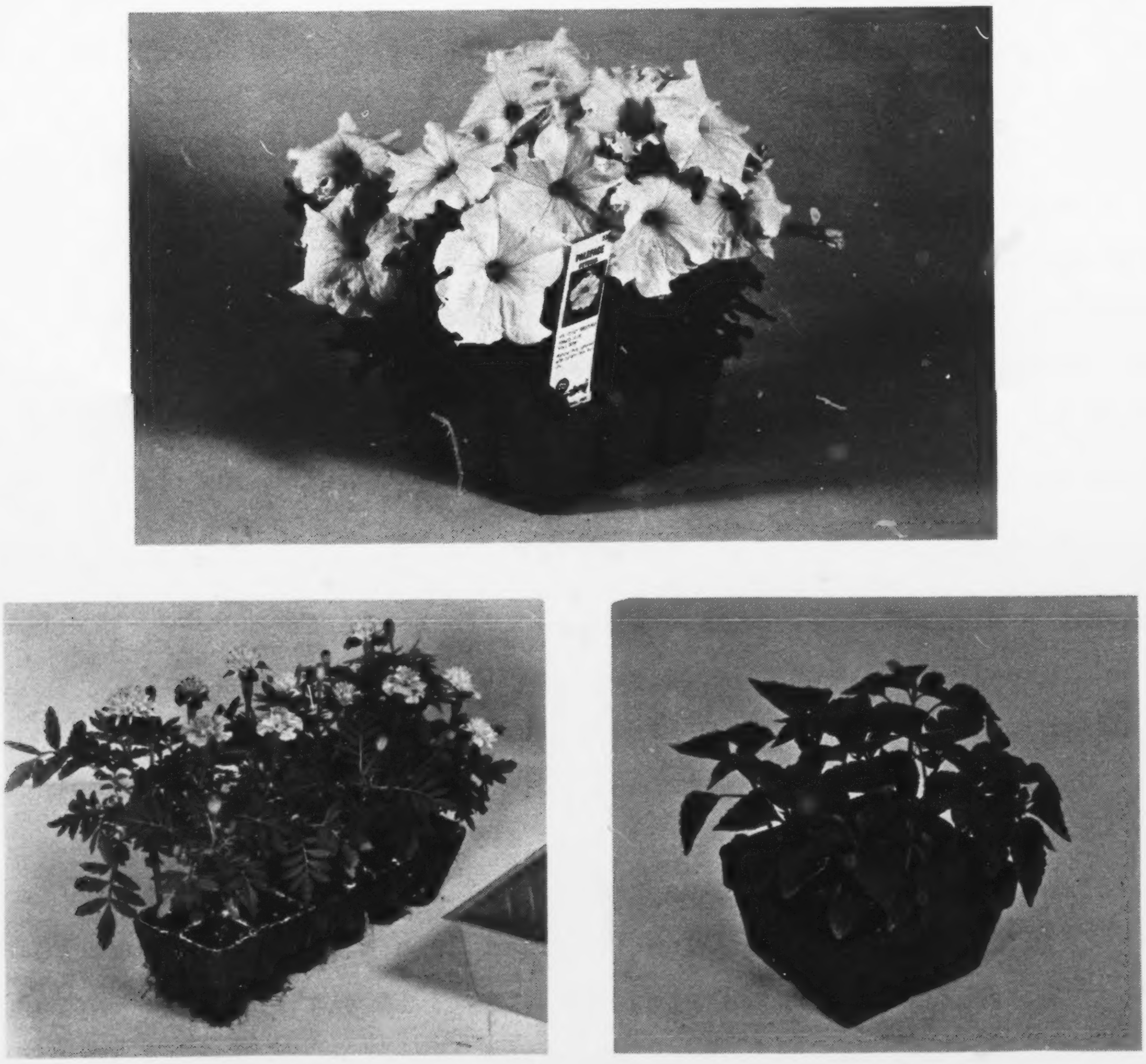


Figure 64. Petunias, top center; marigolds, bottom left; and salvias, bottom right; ready for marketing. (Courtesy, Geo. J. Ball, Inc., West Chicago, Ill.)

Actually, today it would be more accurate to call these plants "flower and vegetable transplants." Most bedding plants, such as petunias, salvias, tomatoes, and peppers, are started from seed because this is the most economical method. Geraniums and a few others are usually started from cuttings. Nearly all of these plants are killed by frost, so they cannot be planted outdoors until the danger of frost is past. The "last frost date" is later in northern states than in southern states, so the propagation schedules for different parts of the country are different. These plants are started in early spring and grown in greenhouses and in coldframes on a schedule that will give plants of suitable size for transplanting outdoors when danger of frost is past in late spring. The flowering ones may or may not be in bloom at planting time, depending upon whether they happen to flower in a size small enough to be successfully transplanted outdoors. Most of these plants are annuals. They are sold in florist shops, garden stores, chain stores, and roadside stands in late spring.

Propagation Schedule

The propagation schedule, Table 11, is set up with successive propagation dates for blocks of plants requiring different lengths of time to reach salable size. Snapdragons, for example, have to be sown on February 7 to give salable plants for May 21, while Muskmelon seeds do not need to be sown until April 15 for the same marketing date.

The propagation schedule is for the northeastern United States, and is set up on the basis of aiming the crops for a May 21 outdoor planting date. The chart following, Figure 65, may be used to determine the appropriate outdoor planting dates for the market being served by a particular greenhouse company. According to this chart, Detroit, Cleveland, Buffalo, and Portland, Maine, are all in the May 21 planting zone. Chicago, Philadelphia, New York, and Boston, however, are in the May 7 planting zone, and all plants being aimed for these markets would be started 14 days earlier than the dates in the schedule in this manual. This propagation schedule should be considered only a guide. A grower may have to make adjustments in it because of local climatic conditions, and local marketing conditions.

Table 11. Propagation schedule for bedding plants in northeastern United States

August 1 - for sale in April, May -
Biennials: pansy, Canterbury bells, foxglove, English daisy
Perennials: delphinium, columbine, others
(Winter these under a mulch in woodframes or mulched outside beds that are well drained)

January 1 - for sale in April, May -
Biennials and Perennials as above - cool greenhouse and move to frames in March or April. Plants grow unchecked and nearly as large as wintered ones

January 1 - for sale May 30 -
tuberous-rooted begonia, geranium from cuttings, F_1 petunia,

February 1 - for sale May 21 -
ageratum, dwarf dahlia, hunnemannia, lobelia, snapdragon, torenia

March 7 - for sale May 21 -
annual phlox, browallia, coleus, cynoglossum, impatiens, all petunias, red salvia, verbena, celery, penstemon, scabiosa, Vinca rosea

March 21 - for sale May 21
anchusa, annual chrysanthemum, annual delphinium, annual dianthus, annual flax, arctotis, blue salvia, China aster, dusty miller, dwarf marigold, flowering tobacco, forget-me-not, garden balsam, gomphrena, heliotrope, nierembergia, portulaca, salpiglossis, sanvitallia, scabiosa, sweet alyssum, "Thumbelina" zinna, thunbergia, tithonia

March 28 - for sale May 21 -
cleome, gaillardia, California poppy

April 7 - for sale May 21 -
celosia (cock's comb), larkspur, tomato, pepper, cabbage, cauliflower, eggplant

April 15 - for sale May 21 -
African marigold, bachelor button, calendula, cosmos, lace-flower, zinnia, muskmelon, watermelon

NOTE: This schedule is for the May 21 planting zone shown in Figure 65 . For other zones, advance or move back the sowing dates by the same number of days as the difference between the outdoor planting date for the May 21 zone and the other zone.

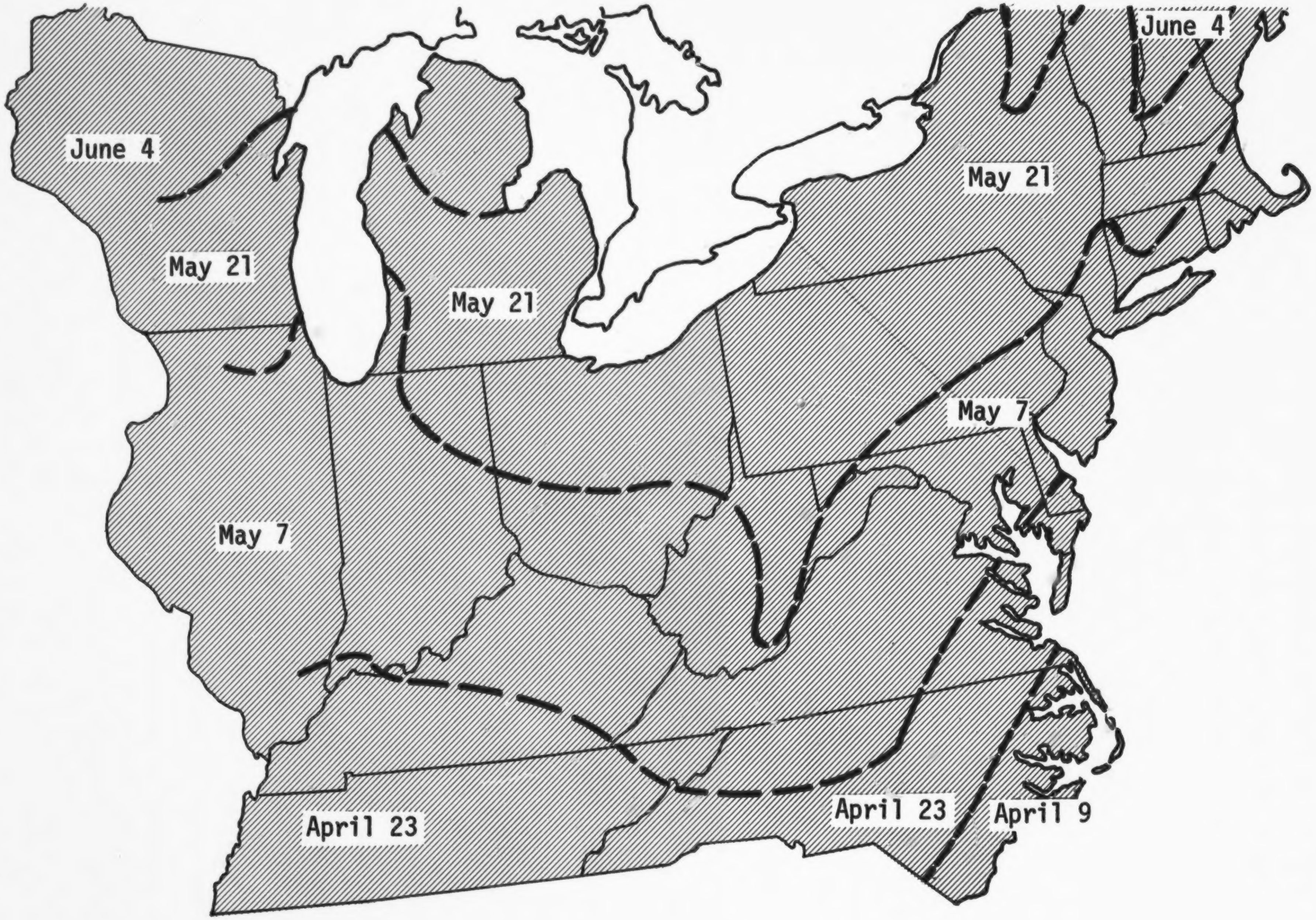

June 4
May 21
June 4
May 21
May 21
May 7
May 7
April 23
April 23
April 9

Figure 65. Marketing dates for flower and vegetable transplants for certain northeastern United States, (7 days after average last frost date in spring).

Quantities

Petunias make up 50 to 60% of the bedding plant crop for the average grower of bedding plants. The quantity of other kinds may vary considerably from one greenhouse to another, even those serving the same market. For many, the geranium would be the second in importance, while additional relatively important ones are salvia, snapdragon, sweet alyssum, dwarf marigold, lobelia, impatiens, African marigold, ageratum, tomato, pepper, and cabbage.

Mediums

Growers must have a reliable source of soil for bedding plants since the soil is sold with the plants. The medium must be well prepared and have good drainage. All mediums should be sterilized by steaming. Soil mediums used for germination and growing have different proportions of ingredients. Artificial soil mixtures of peat with Perlite, Vermiculite, or fine sand may be used. These have the advantage of being uniform from year to year. Fertilizer, such as "Osmocote," must be mixed uniformly in these mixtures.

Germination mediums usually include equal parts (1-1-1) of loam topsoil, peat, and sand or perlite. However, a mixture of two parts soil, 1 part peat and 1 part medium to coarse sand is used by many growers. No matter which is chosen, it should be light, porous, well-drained, and fairly low in fertilizer content. It is possible to use mixtures without soil such as equal parts of peat and fine Perlite, or peat and fine Vermiculite. These mixtures do not retain fertilizer well, so it is important to add diluted soluble fertilizer at a regular schedule.

The soil medium for transplanted seedlings should be well-drained and easy to manage. Growing mediums should have more water and nutrient holding capacity than a germinating medium. Growers usually add more topsoil to the growing mixture to provide these characteristics. Where topsoil is not easily obtained, artificial mediums may be used. Artificial mediums are uniform in texture, light in weight, and in many cases,

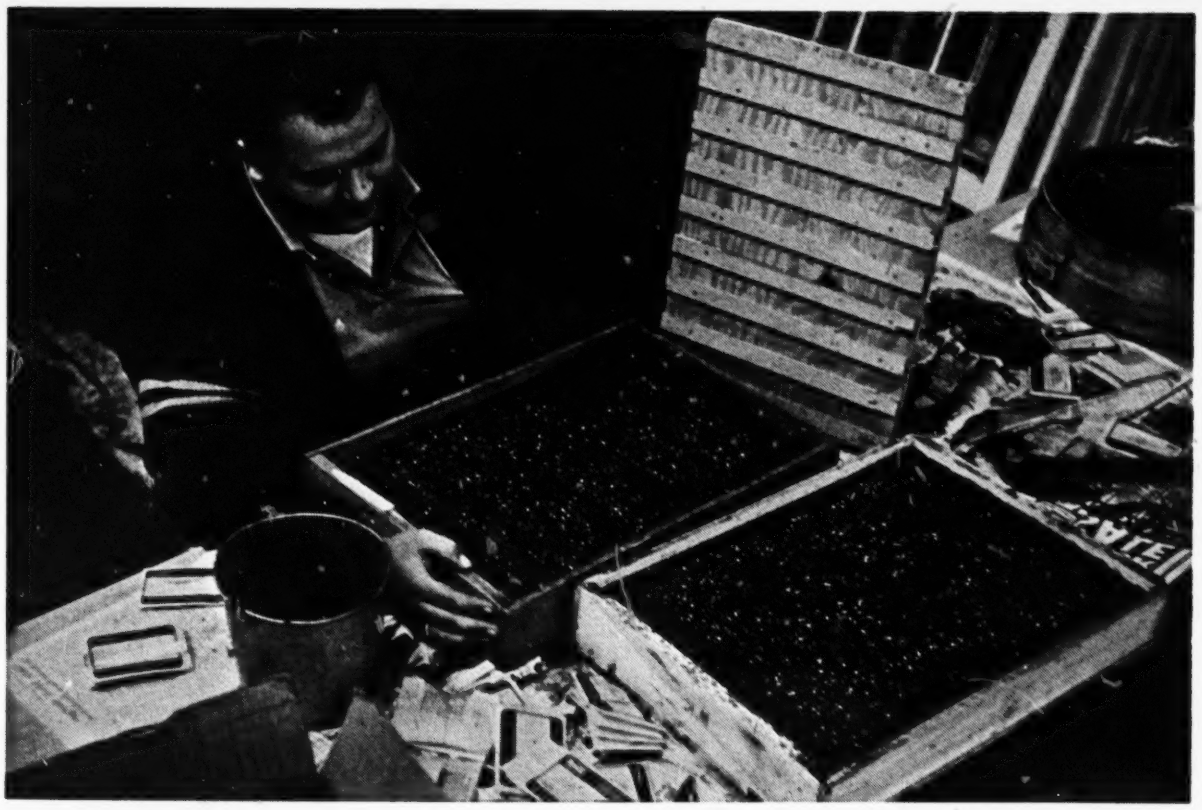


Figure 66. A row marker is used to prepare a flat for seeding.

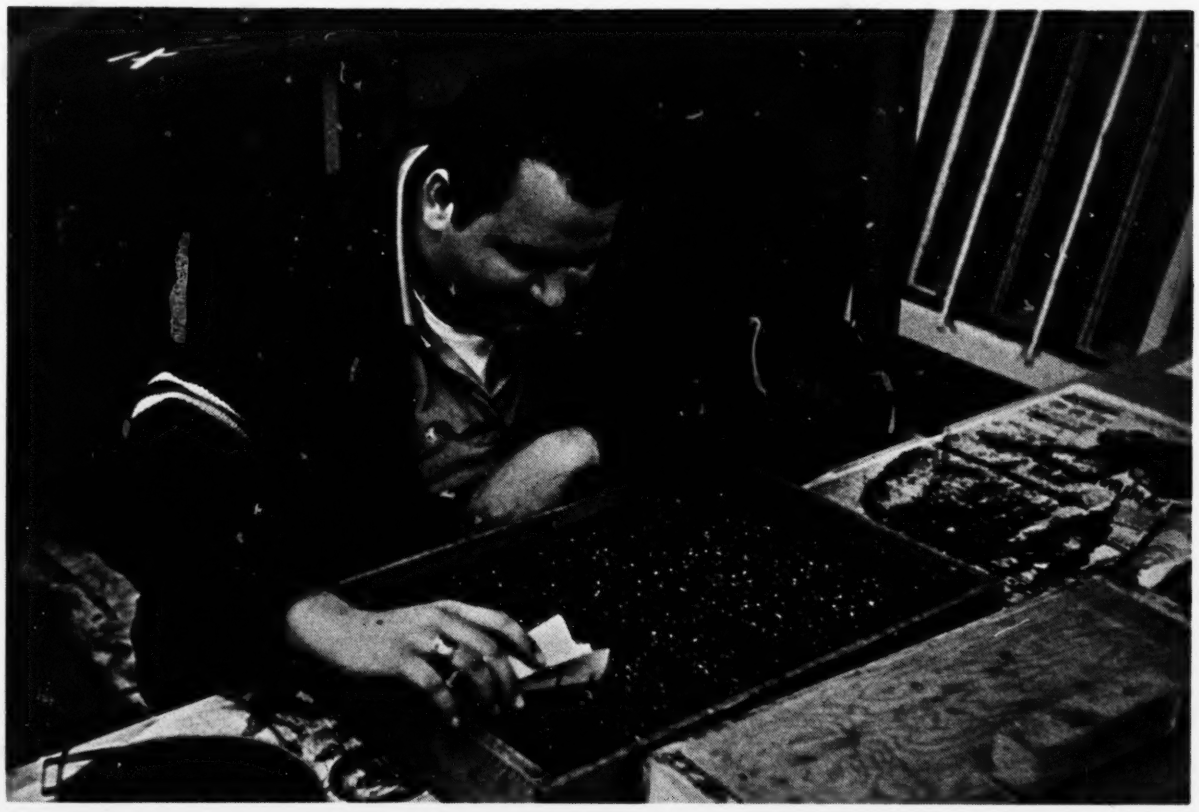


Figure 67. Seeds are sown in 1-inch rows by gently tapping the seeds from the packet.

comparable to topsoil. These soils require frequent watering to prevent drying and injury from soluble salts.

Seed Sowing

The soluble salt level in soil for seed sowing and for transplanting seedlings should be within the range of 15 to 25.

As a rough guide, with petunias, 1 trade packet (1/128 ounce) of seed is enough for an average size flat.

Fine seeds are usually sown in very shallow depressions made about 1 inch apart in the surface of the soil. A wooden row marker may be used for making these depressions. Plants having fine seeds are petunias, snapdragons, begonias, and others. Just prior to seed sowing, the leveled soil in the flats is watered with a gentle spray of water. Seeds are sown directly from the opened seed packet by holding the open end over the groove in the soil and gently tapping the packet to cause the seeds to fall out. As the seeds fall, the packet is moved along the row. The seeds should be spaced 1/8 to 1/4 inch apart. A very thin layer of peat is then screened over the soil. A piece of window screening, mounted in a frame, may be used for this purpose -- the peat being rubbed through it. The layer of peat should be just thick enough to hide the color of the soil.

Large seeds are sown in depressions about 1/4 inch deep, and the soil mixture is then sifted over them just enough to cover the seeds.

Another way to handle large seeds is to sow them directly in the containers in which they are to be sold. Two or three seeds are placed in each hole where a plant is wanted. The containers are then handled in the same way as any other seed germination container. When the seedlings are 1 to 2 inches high, excess ones are cut off at the soil surface with scissors. Marigold, zinnias, tomatoes, peppers, and cabbage are often handled this way.

Figure 68 . Properly prepared label for a seed flat (use pencil!)

Each seed flat should be carefully labeled immediately after the seed is sown so that there is no chance of a mix-up later. Wooden labels are used for this purpose. The name of the plant and the cultivar (variety) is written on one side of the label, and the sowing date is placed on the other side. It is important to do this in pencil -- ink will wash off in the first watering.

Moisture

All seed flats should be watered immediately after the seeds have been sown. If an automatic mist system, with "bottom heat" is available, the seed flats may be placed under the mist and remain there until the seeds have germinated. An alternative to this is to thoroughly water the flats, using a fine, soft spray so as not to disturb the seeds, and then wrap the flats in polyethylene film. They are then placed where the temperature is about 65 to 70°F. The wrapped flats must not be placed in full sunlight, or excessively high temperatures may develop. In fact they should be kept in subdued light. The film keeps them from drying during the 3- to 14-day germination period. The important thing in this method is that the flats must be checked each morning and each afternoon to see whether the seeds have germinated. At the first sign of germination, the film must be removed and the flats should be placed where they get as much sunlight as possible. Failure to do so is to invite very rapid development of damp-off. Once the seeds have germinated, the plants should be watered as much as any other plants -- usually they will need water once every day or two depending upon the weather and the rate of growth of the plants. Damp-off is often prevented by providing gentle air circulation with a household fan positioned so the main blast of air is 3 feet above the seedling flats.

Temperature

Nearly all bedding plant seeds require a medium temperature of 65° to 75°F for good germination. Many growers supply this warmth by using electric cables embedded in sand on which the flats are placed. Some use cutting propagation benches which have heat pipes under them, with skirts on the sides of the benches to force the heat upward through the propagation medium. Recently, electrically heated plastic mats on which the flats may be placed, have been developed. They work very well. Each mat has a capacity of about 6 flats.

Containers

Containers for bedding plants come in many sizes and shapes and may be made of wood, peat, plastic, fiber, or fired clay. Some of the kinds commonly used are shown below and on the following pages.

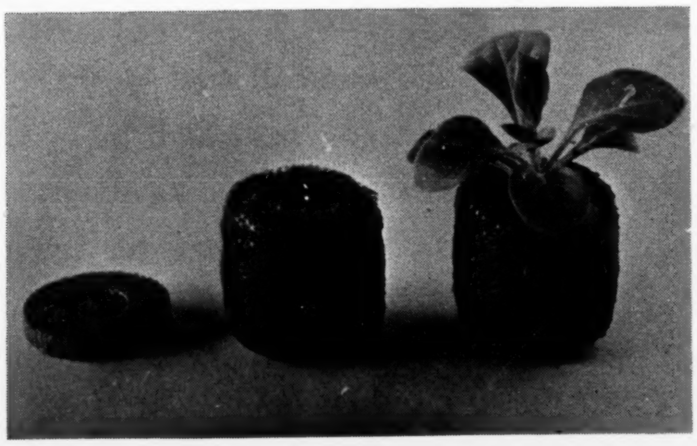


Figure 69. Peat pellets are a combination of peat and long lasting fertilizer enclosed in a plastic mesh. When watered they expand to 7 times the original size. Cuttings, seeds or seedlings are planted in them. The consumer plants the whole unit.

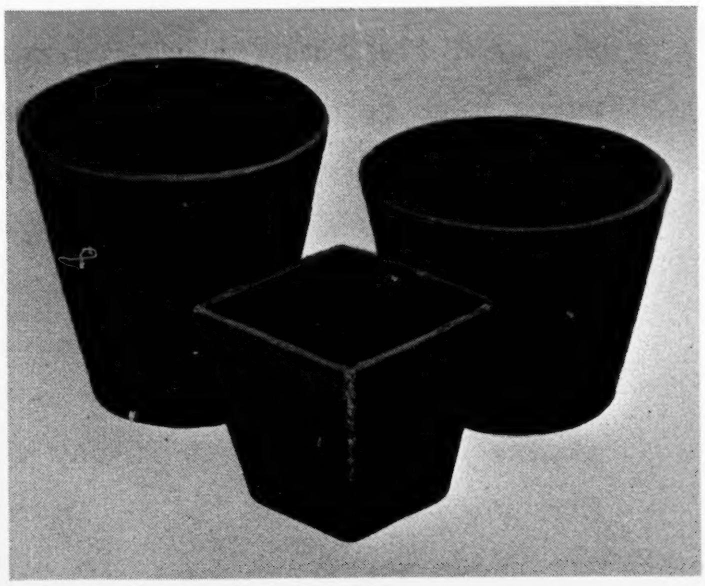


Figure 70. Pressed peat pots are designed to be planted with the plant. Plants may be grown in them for 2-1/2 months, or longer. Several sizes are available. Many consumers prefer this container.

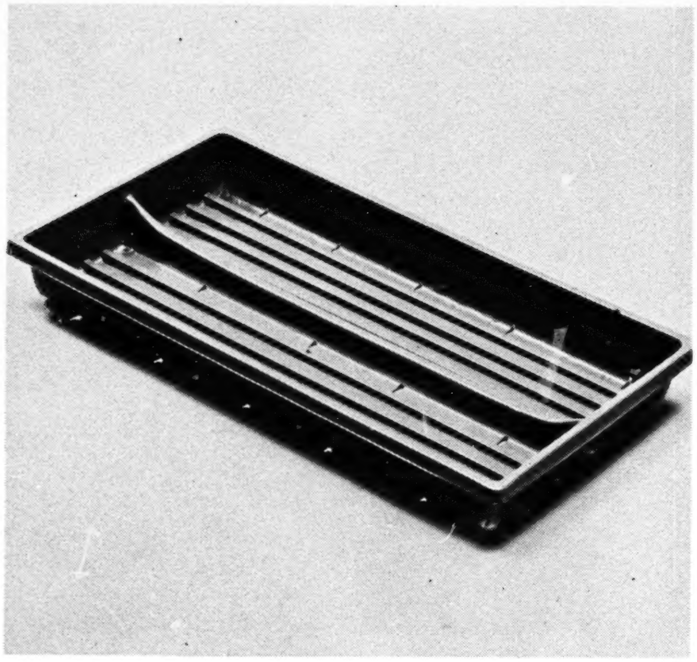


Figure 71. Flats are made of wood or plastic. Dimensions vary. Skeleton flats are designed to hold a number of smaller containers.

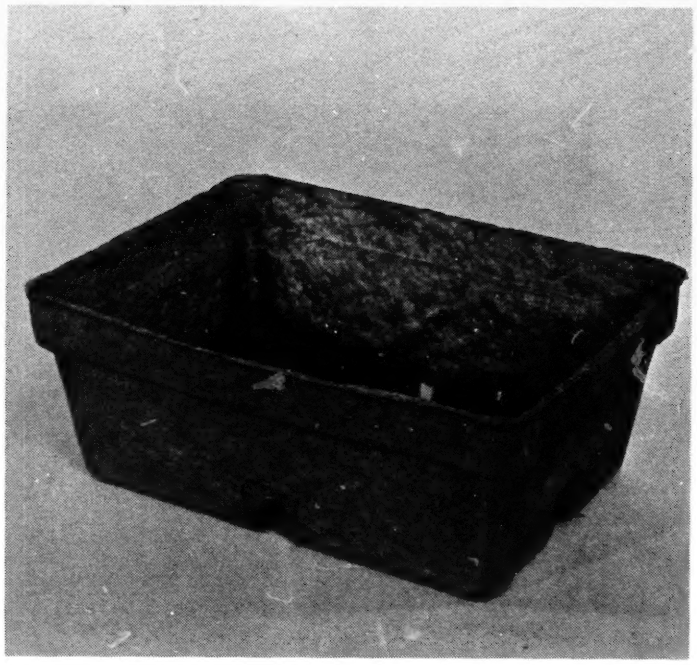


Figure 72. Packs are made of an asphalt-treated composition. They come in many sizes and shapes. They are usually planted with 6, 9, 12, or 24 plants.

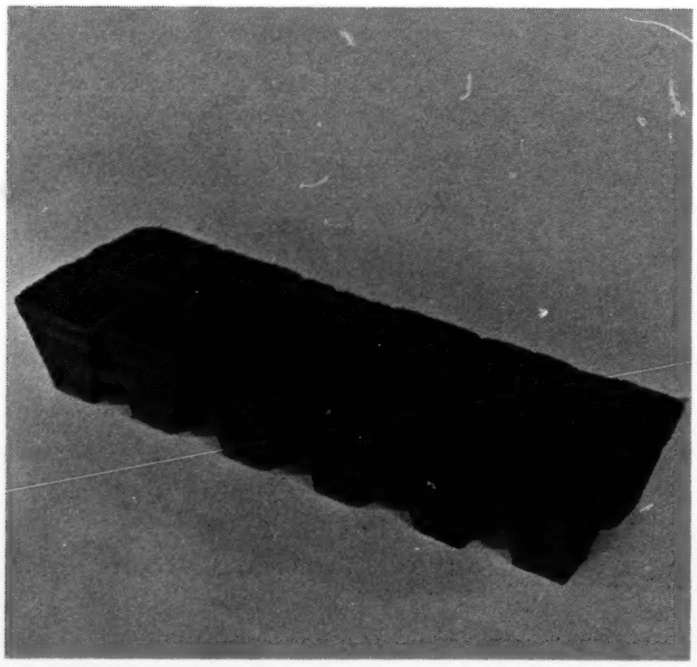


Figure 73. Pressed peat strips consist of square pots joined at the top rim in units of 12 for convenient handling.

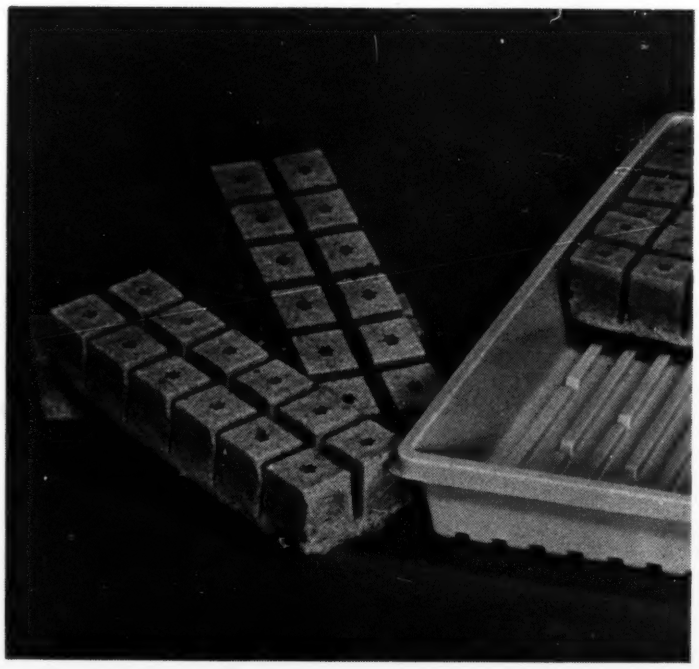


Figure 74. Cellulose fiber blocks are used in the same manner as peat pellets but are joined in cakes of 12.

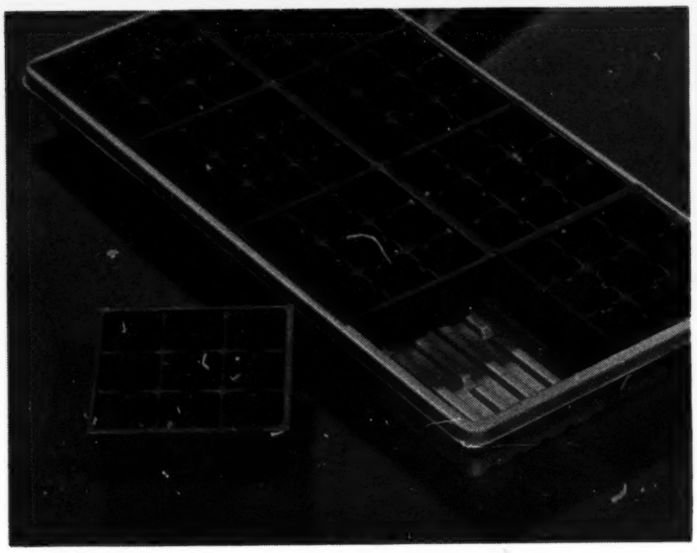


Figure 75. Plastic trays are available in many sizes and shapes. The dimensions are such that multiples of them fit snugly into a large flat.

Figure 76. Clay pots have good stability because of their weight, but they are less easily handled for the same reason. They are often used for geraniums, tomatoes, melons, and large size petunias.

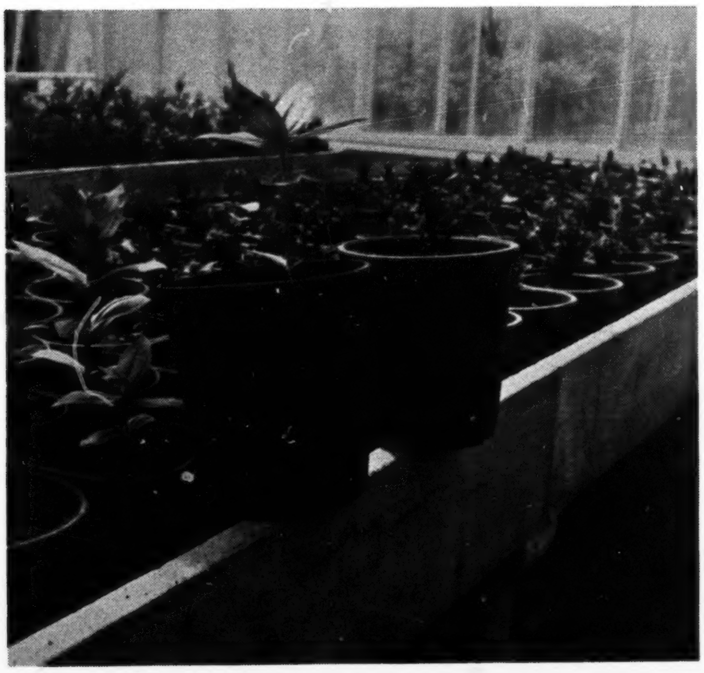


Figure 77. Plastic pots are thin-walled round or square pots which are sold with the plants. They are often used for geraniums, tomatoes, melons, or large petunias. Square ones are obtainable joined together in strips or squares.

(Photographs for Figures 69 through 77 , courtesy of George J. Ball, Inc., West Chicago, Illinois)

Fertilizing

Proper fertilizing results in strong, fast growing seedlings that transplant with less shock than those that have not been properly fertilized. The application of a 1/2-strength soluble fertilizer high in phosphorus (a 9-45-15, for example) just as the seeds are germinating will result in a more even stand of plants with dark green leaves. This is often called a "starter solution." This fertilizer, at the same rate, should be applied to the seedlings about 2-3 days before transplanting. This results in plants that are less sensitive to shock and that will start growing faster after being transplanted.

Transplanting

Transplanting must be done at precisely the right stage of seedling growth, or damage to the plants will delay their growth. They should be transplanted when the "true" leaves are expanding. The first leaves to appear are the "seed" leaves, or cotyledons. The next leaves to appear have the typical leaf shape of the mature plant and are referred to as the "true" leaves.

If seedlings are transplanted before the "true" leaves are expanding, the tissues are too soft to handle. Handling at this stage results in bruising of the tissues, which are then very subject to rotting diseases, and plant losses may be very high.

On the other hand, if transplanting is delayed until the second set of "true" leaves has started to expand, the root system has become so extensive that much of it will be broken off when the seedlings are lifted out of the seed flat. Again, losses may be very high due to disease as well as the inability of the root system to keep up with the water needs of the plant.

Seedlings are transplanted into containers in which they will be marketed. Usually these are small trays with a capacity of 6, 9, or 12 plants. The seedlings are usually spaced about 1-1/2 inches apart in these containers.

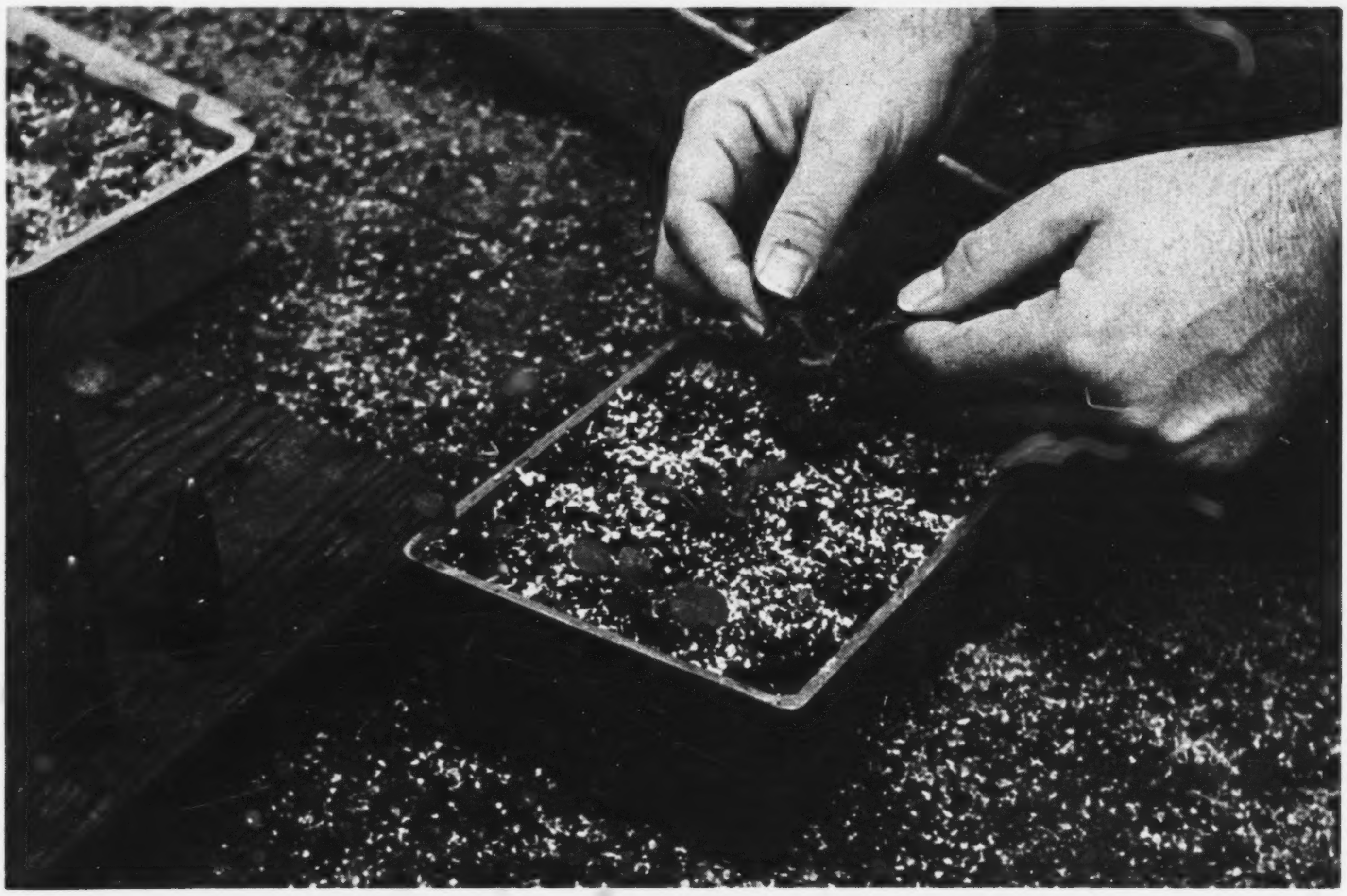


Figure 78. Bedding plant seedlings should be handled by the leaves when transplanted.

Transplanting involves making holes in the soil in the container to receive one seedling each. A dibble board, which can make many such holes at one time is often used. A label, or a small flatted stick, is slid under the seedlings in a seed flat, and by gently lifting, the plants are loosened from the soil. The worker then gently grasps each seedling by a leaf, lifts it out of the seed flat,and transfers the plant to the hole. Still holding it with the same fingers, at the same soil depth at which the seedling originally grew, he then firms the soil around the roots with the label originally used for loosening the seedlings in the seed flat. Deep planting is likely to result in rotted stems and dead plants. The steps are repeated until all the holes in the container have been filled with plants. It is important to handle the seedlings only by the leaves. Handling by the stem may result in fatal bruises.

Each seedling container should be thoroughly watered immediately after transplanting has taken place. Wilting at this time can severely damage the young plants. To prevent excessive wilting, plants are usually shaded from strong sunlight for 2 or 3 days after transplanting.

Purchased Seedlings

Seedlings at just the right stage for transplanting into the containers in which they will be sold, may now be purchased from specialists who germinate the seeds and grow the young plants to this stage. These are started in growth chambers with precisely controlled temperature, light, relative humidity, moisture, and nutrition.

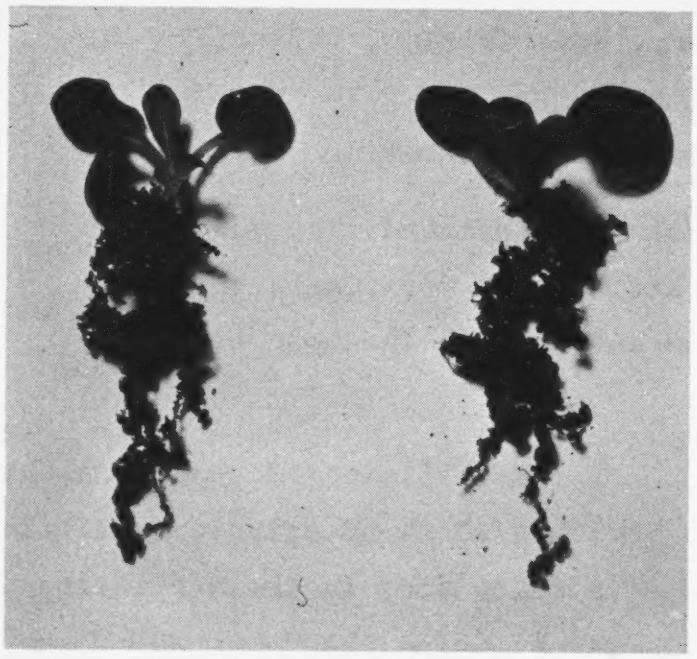


Figure 79. Petunia seedlings, from a growth chamber, at the right stage of growth for transplanting by a bedding plant grower who has purchased them for "growing on."

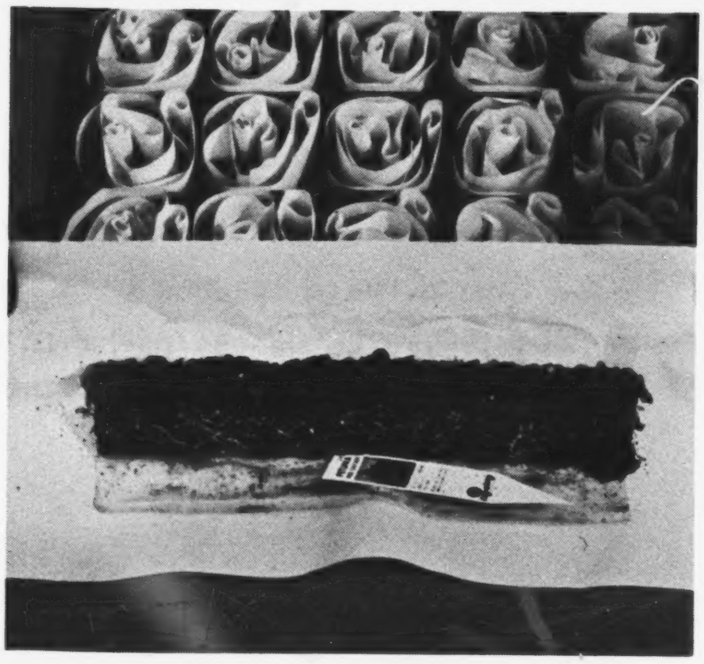


Figure 80. A strip of 100 petunia seedlings, from a growth chamber, ready for shipment.

(Courtesy, Geo. J. Ball, Inc., West Chicago, Ill.)

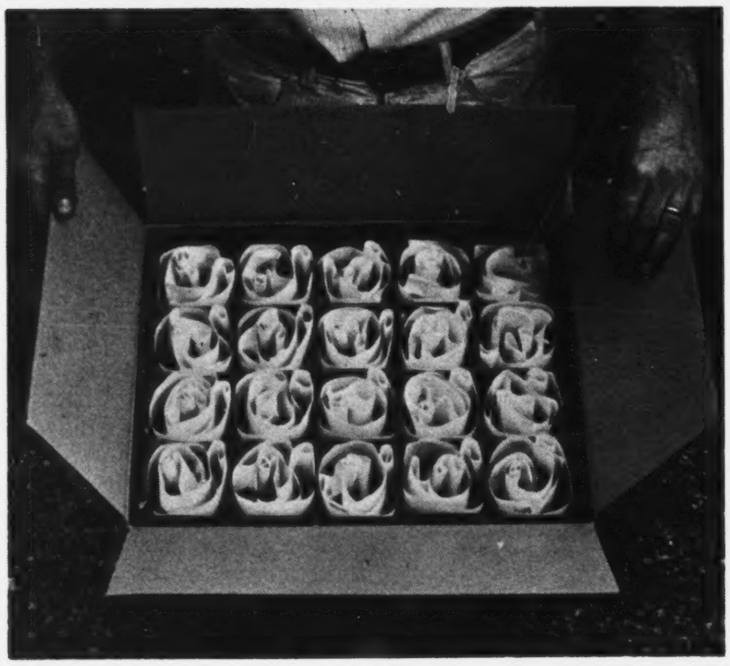


Figure 81. Spirally wrapped strips of bedding plants in a carton ready for shipment to a bedding plant producer.

(Courtesy, George J. Ball, Inc., West Chicago, Illinois)

Culture from Transplanting to Marketing

Watering of bedding plants is often done by hand, but an "Ooze" hose type of watering has been successfully used for plants in packs by simply lining up the packs in a row and running the hose between the plants the full length of the row.

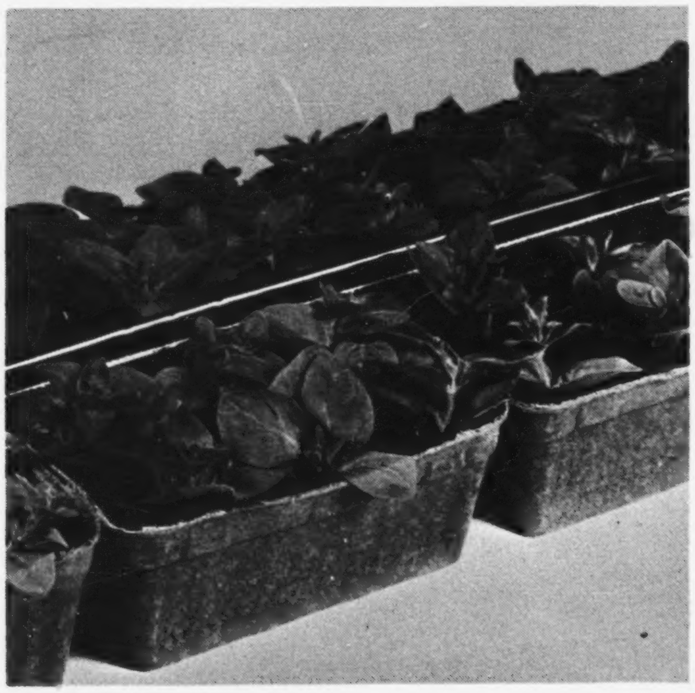


Figure 82. "Ooze" hose watering of bedding plants.

Fertilizing of bedding plants with a 20-20-20 soluble fertilizer is often done in the irrigation water, using the "constant feed" program. For this, the 200 ppm N rate is used as given on page 51. An injection device is used for this purpose. Fertilizer may be applied on a weekly basis, in which case 2 ounces of a 20-20-20 water soluble fertilizer should be dissolved in 2-1/2 gallons of water, which is applied directly to the plants. If the fertilizer is applied at 2-week intervals, then the amount per 12-1/2 gallons is doubled at 4 ounces.

Night time temperatures of 60°F should be used during the 4 to 5 weeks after transplanting. Lower temperatures at this stage of growth will delay the crop. After this early growth period, the night temperature may be gradually lowered to 50°F, and the last week or two, to 45°F. This lowering of temperature gives stiffer stems, harder leaves, and darker colored flowers. Bringing about these changes with lower temperature is called "hardening" the plants. Bedding plants are often "hardened" in coldframes, which are left uncovered except during those nights when a frost is predicted. Certain annuals, such as snapdragons, petunias, pansies, and sweet alyssum can tolerate temperatures as low as 25°F if they have been previously "hardened." Frosts are fatal to tomatoes, peppers, and many flowering plants.

Growth-regulating chemicals can be used to give more compact bedding plants, just as they are used to give more compact potted chrysanthemums as discussed on page 79. Petunias present a special problem, which may be solved in part by the use of a growth regulator called B-Nine. Petunias tend to elongate very rapidly in the high temperatures and long days of late spring. If unfavorable spring

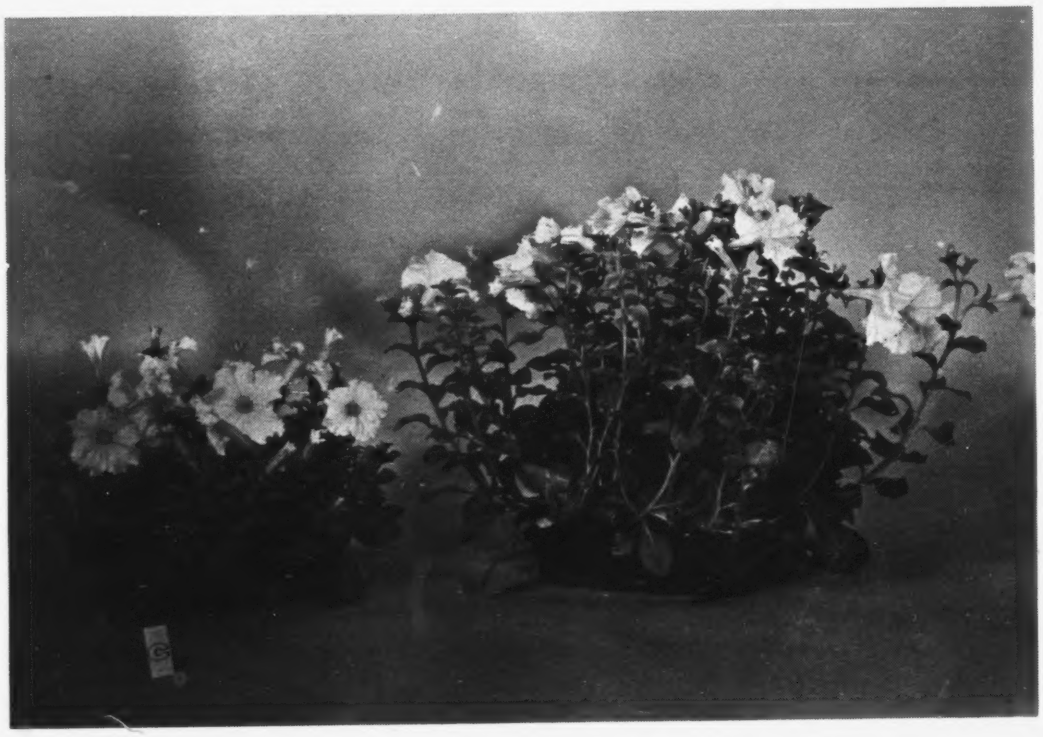


Figure 83. Height control on "White Magic" petunia. Plants had identical handling except one on left was sprayed with B-Nine. (Courtesy, George J. Ball, Inc., West Chicago, Illinois)

weather delays sales of these plants at the usual market time, they become straggly while waiting to be sold. The use of B-Nine actually increases the "shelf life" of petunias and a few other bedding plants. At the sixth leaf stage (about March 15 from a late February sowing), the plants should be placed under 8-hour daylengths (by the use of black cloth as for chrysanthemums) to cause compact growth and branching. This special photoperiod treatment is ended about 4 to 5 weeks later, or about April 15. The main stem will start to elongate about May 1. At that stage of growth, the plants should be sprayed with B-Nine according to the directions on the container. The plants must not be watered for 24 hours after the B-Nine is sprayed on the tops, otherwise the material will be diluted and the effect lost. This treatment prevents stem elongation. Flowering is not delayed by this treatment, and the plants grow out of the compacting effect about 4 to 6 weeks after treatment, which is usually a week or two after the customer has planted them in a garden. Certain petunia cultivars respond better to this treatment than others. Additional annuals which may be effectively treated with B-Nine are: aster, marigold, salvia, verbena, and zinnia. For more details on controlling growth, read pages 61 through 73 in Reference No. 4. Bedding Plants - A Penn State Manual.

Some diseases that may be troublesome are leaf spots, mildew, and botrytis. Insects that may cause damage include: two-spotted mites, aphids, thrips, and white flies. Control measures for these pests appear on pages 58 through 61.

Marketing

The bulk of bedding plants are produced by large greenhouses and are sold to retail outlets through advance verbal contracts. These contracts are often made in June just after the main sales period. At that time the retailer has a good idea of the kinds and quantities that are most likely to sell through his store the following year. A written record of this oral contract is usually kept by both the retailer and the greenhouse manager. Small greenhouse companies may sell directly to retail customers, but most sales are through garden stores, flower shops, roadside stands, and chain stores.

Customers prefer plants grown in single containers in quantities of 6, 9, 12, or 24. They also like certain kinds that have been grown in individual containers. Consumers are realizing how easy it is to handle plants which may be planted in the garden, container and all. They also are keen judges of good quality and spend considerable time selecting the plants they want. Another important point is that the plants must be in the store at the time the customer wants to buy them.

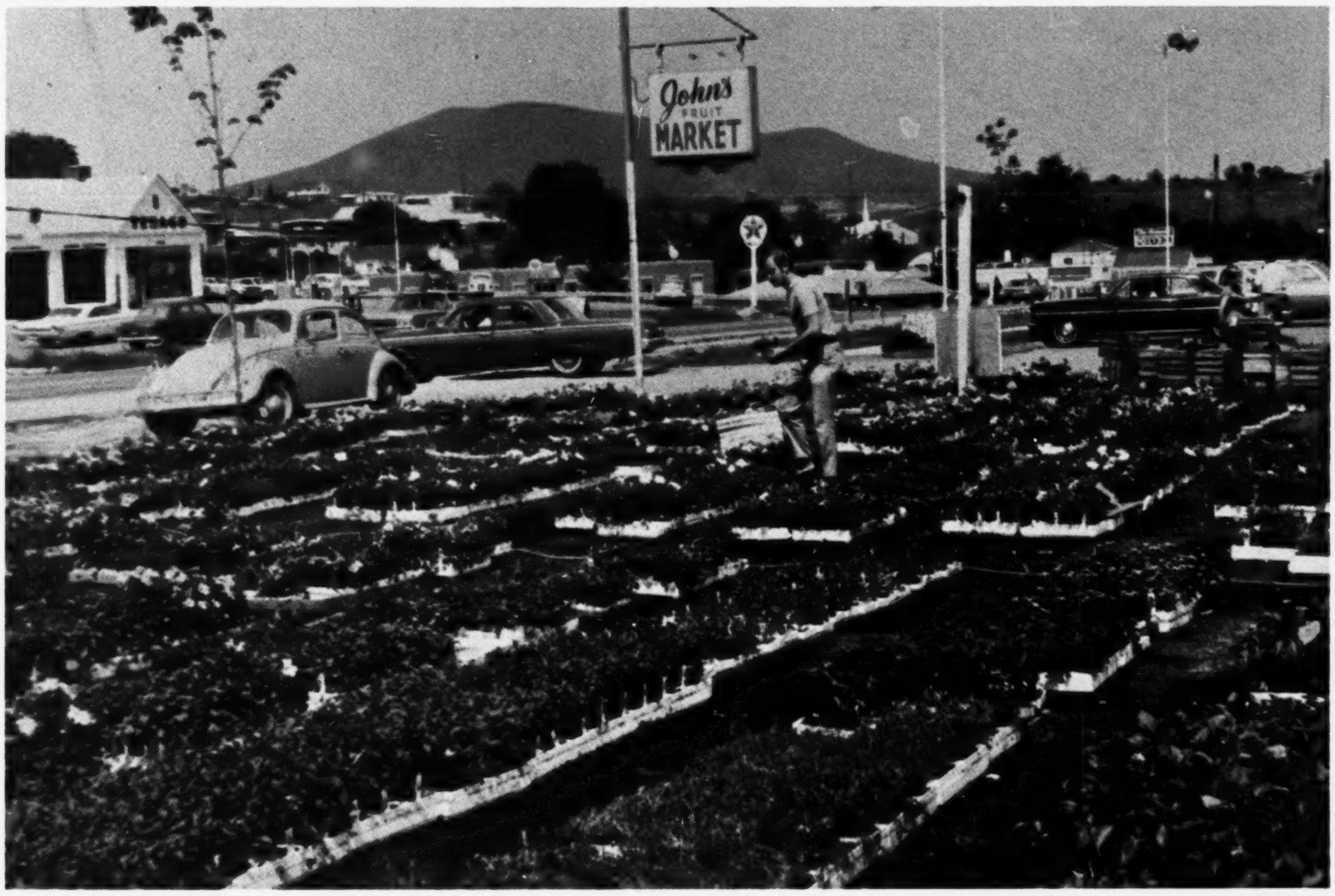


Figure 84. Bedding plants on display at a garden store.

A producer of bedding plants has to consider all these things so that he can effectively plan his bedding plant operation for the next year. A good discussion of costs and prices appears on page 94 through 98 in Reference No. 4, Bedding Plants - A Penn State Manual.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Bedding plants command an extremely large market and care should be taken to produce a desirable crop for sale. The majority of the bedding plants are relatively easily grown and would offer valuable experience to students. Plants such as those grown from seed could be followed through to a beautification project at school and throughout the community.

Learning Resources

Supplies:

Seed and supply catalogs from wholesale firms.

References:

1969 Ball Catalog. George J. Ball, Inc., West Chicago, Illinois

Bedding Plants - A Penn State Manual. Reference No. 4

The Ball Red Book, 11th edition, 1965, Reference No. 29

Commercial Flower Forcing, Seventh Edition, Reference No. 7

The U. C. System for Producing Healthy Container-Grown Plants, Reference No. 32

Suggested Learning Activities

1. Divide students into teams of 2 to 4 and start a few popular kinds of bedding plants from seeds and have the students follow their plants through a desirable schedule until they are ready to be marketed. Have each team keep a notebook on the procedures they followed and noticeable effects of those procedures. These notes can be compared at the conclusion of the exercise.
2. This would be a good point at which to review plant structures -- cells, tissues, meristems, roots, stems, and leaves, and to discuss the functions of each. Pages 63 through 67 of Commercial Flower Forcing, Seventh Edition, are a good reference. The use of living material and a microscope by students is recommended.

3. Have the class sow a few beans, radish, and corn seeds at weekly intervals for 5 weeks. At the end of the sixth week wash the soil from the roots and have each student arrange a set of each before him in chronological order. Have students trace the development of hypocotyl, cotyledons, plumule, root, stems, and leaves.

Test

1. Why is the term bedding plants inaccurate?
2. What is a dibble board and why is it used?
3. What is vermiculite and from what is it made?
4. Which of the bedding plants is considered the most popular?
5. What would be considered a good germination medium for bedding plants?
6. What is the proper method of sowing seed in a seed flat?
7. If an automatic mist system, with bottom heat is not available, what alternative method is used?
8. What is the temperature of the medium required by most bedding plants?
9. Why should fertilizer be applied just as the seeds are germinating?
10. What is the correct stage of seedling growth for transplanting?
11. Explain the proper method of transplanting seedlings.
12. Why should the night time temperatures be gradually lowered after transplanting?
13. What chemical is commonly used to control height of petunias?
14. Why do customers prefer plants grown in single containers?
15. What problems occur if bedding plants are transplanted before the true leaves appear or after the second set of true leaves appear?

POTTED PLANTS UNIT 5

Additional Crops

Learning Objectives

To develop a basic understanding of the cultural requirements for the following crops:

1. Geranium
2. Rose
3. Azalea
4. Hydrangea
5. African Violet
6. Foliage Plants
7. Spring flowering bulbs

Key Questions

1. What is the recommended light intensity for geraniums?
2. For which holidays are potted roses produced?
3. What is the recommended type of soil for azaleas?
4. For which holidays are hydrangeas most popular?
5. How are African violets propagated?
6. What time of year do producers sell the most foliage plants?
7. How deep should bulbs be planted?

New Words

"Cultured" cuttings - cuttings certified to be disease-free

Floribunda - a class of rose cultivars with many small blossoms in clusters

Forcing - growing plants out of their normal season by use of an artifical environment

Post-cooling - plants about to flower ahead of schedule are slowed by lowering the temperature

Leaf petiole cutting - leaf with attached petiole used for producing a new plant

Foliage plants - plants grown for foliage beauty as compared with flowers

POTTED PLANTS UNIT 5

Geranium

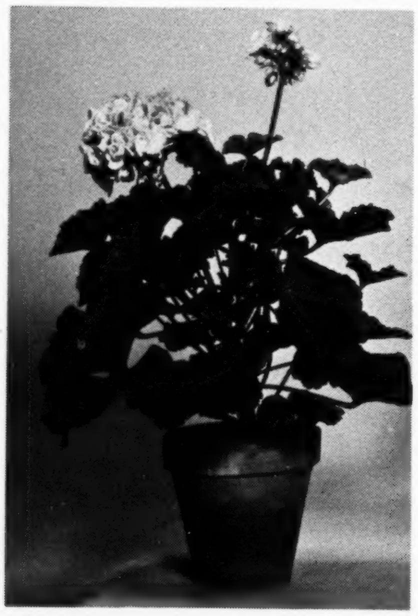


Figure 85 . Geranium
(Pelargonium hortorum)

Sales Period - Mother's Day (mid-May), Memorial Day (end of May), also through June

Propagation - seed, mid-January, 70°F bottom heat; rooted cuttings potted March 1. "Cultured" cuttings highly recommended

Pot Size - 4", 3", some in packs

Soil - porous, not too high in organic matter; steamed

Light Intensity - full sun, light shade in May

Temperature - 60°F for growing; 55°F for holding

Nutrition - 15-15-15 in irrigation water at 75 ppm N rate; high N gives poor flowering and heavy foliage; low K gives brown leaf margins

pH - 6.0 - 7.0

Soluble Salts - below 80 "K"

Watering - may be allowed to wilt slightly between waterings

Pests - white flies, two-spotted mites

Diseases - Pythium rot, bacterial stem rot, Verticillium wilt, Botrytis blight, viruses, odema

References:

The Penn State Geranium Manual. 1970. Reference No. 31

1967 Cornell Recommendations for Commercial Floriculture Crops. Reference No. 10

POTTED PLANTS UNIT 5

Rose

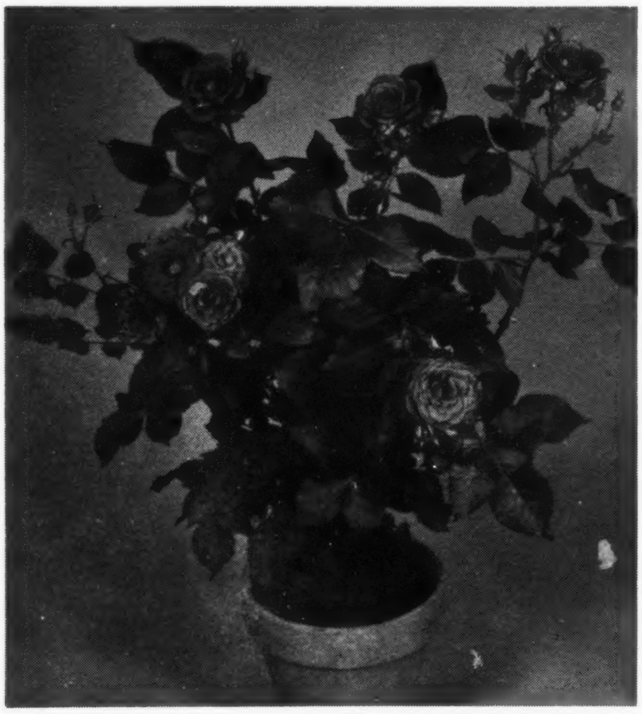


Figure 86. Rose (Rosa hybrid) Sweetheart Type (Floribunda) (Courtesy, George J. Ball, Inc., W. Chicago, Illinois)

Sales Period - Valentine's Day, Easter, Mother's Day, Memorial Day

Propagation - purchase forcing size, dormant plants; ordered one year in advance; pot upon receipt, water, and hold at 35°F to 40°F until forcing time

Pot Size - 7", standard for sweetheart type, 4" standard for miniature type

Soil - standard mixture, well drained

Nutrition - 20-20-20 in irrigation water at 150 ppm N rate; or soluble at 2-week intervals

pH - 6.0 - 7.0

Forcing Schedule (1970 example, adjust for future years, see Appendices)

Condition	Valentine's Day	Easter	Mother's Day	Memorial Day
Start at 50°F	11-4	1-5	2-20	3-15
Raise to 55°F	12-1	1-25	3-13	4-5
Raise to 60°F	12-15	2-6	3-27	4-19
Buds visible	1-3	2-17	4-9	5-9
Buds in color	2-1	3-17	4-30	5-26
In bloom	2-14	3-29	5-10	5-30

Watering - do not allow to wilt

Pests - aphids, two-spotted mites, thrips

Diseases - powdery mildew, black spot

Recommended cultivars:

Sweetheart Type: Bright Pink Garnette, Carol Amling, Dick Koster, Garnette, Orange Rumba, Margo Koster, Mother's Day, Pink Marvel, Scarlet Marvel, Skylark, Summer Snow, Thunderbird, Triumphe d'Orleans

Recommended cultivars:

Miniature Type: Baby Gold Star, Bo-Peep, Chipper, Cinderella, Eleanor, Midget, Pixie, Pixie Gold, Pixie Rose, Red Imp, Scarlet Gem, Starina

References:

Commercial Flower Forcing. Seventh Edition. Reference No. 7.

Roses Manual. Reference No. 27.

POTTED PLANTS UNIT 5

Azalea

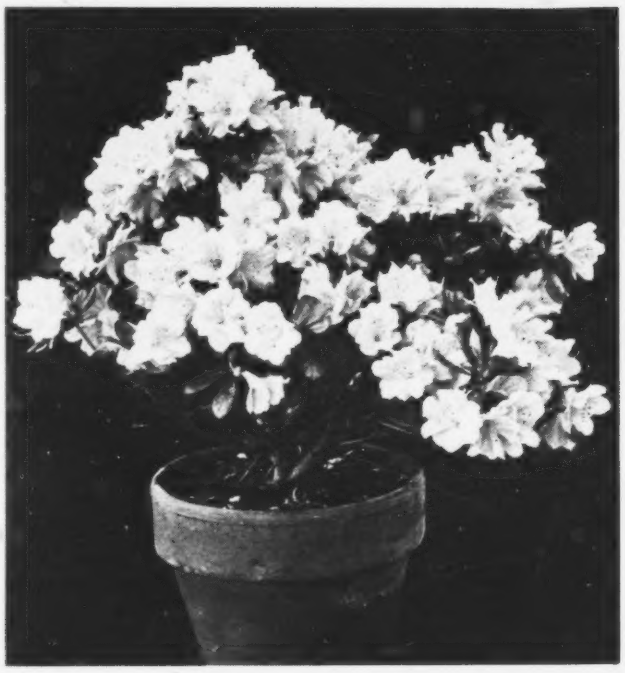


Figure 87. Azalea
(Rhododendron hybrid)

Sales Period - Christmas, Valentine's Day, Easter, Mother's Day, (a few year around)

Propagation - purchase dormant, budded, precooled, plants for forcing (for culture to this stage see reference)

Pot Size - 4", 5", 6" "azalea" pots; the same size in which shipped

Soil - coarse peat

Forcing Schedule (1970 example, adjust for future years, see Appendices A&B)

Group	(1969) Thanksgiving		Christmas		(1970) Valentine's Day		Easter		Mother's Day
	A	B	A	B	A&B	C	AB&C	D	ABC&D
Start at 50°F	10-31	10-16	11-28	11-14	1-17	1-3	3-17	3-1	5-3
60°F-65°F	11-7	10-23	12-2	11-21	1-27	1-10	3-24	3-8	
Buds show color	11-22	11-22	12-18	12-18	2-7	2-7	3-25	3-25	
In bloom	11-27	11-27	12-25	12-25	2-14	2-14	3-29	3-29	5-10

Fertilizing: None

Forcing Groups:

A Coral Bells, Coral Bells Supreme

B Ambrosier, Alaska, Albion, Alice Mueller, Apricot Queen, Chimes, Chimes Sport, Constance, Delight, Dorothy Gish, Dr. Bergman, Early Wonder, Eclaireur, Eric Schame, Gloria, Firelight, Hexe, L. C. Bobbink, Mme. Petrick, Orange King, Paul Schame, Perle de Sweynaarde, Pink Ruffles, Pocahontas, Purity, Red Cap, Red Wings, Rhapsody, Rose Queen, Salmon Glow, Snow, Snowbank, Snow Queen, Sunset, Triumphe, Vervaeneana, Westwood Red

Forcing Groups:

C Albert and Elizabeth, Empress of India, Glory of Easter, Jean Haerens, Knute Erwin, Mrs. Fred Sanders, Sweetheart Supreme

D Baby Pericat, Easter Parade, Marjory Ann, Mme. Pericat, Pericat, Pink Pericat, Rose Pericat, Sun Valley

Post-Cooling:

Advanced plants can be held in unlighted 35°F storage at the "bud color" stage for 2-4 weeks.

Reference:

Commercial Flower Forcing, Seventh Edition. Reference No. 7.

POTTED PLANTS UNIT 5

Hydrangea

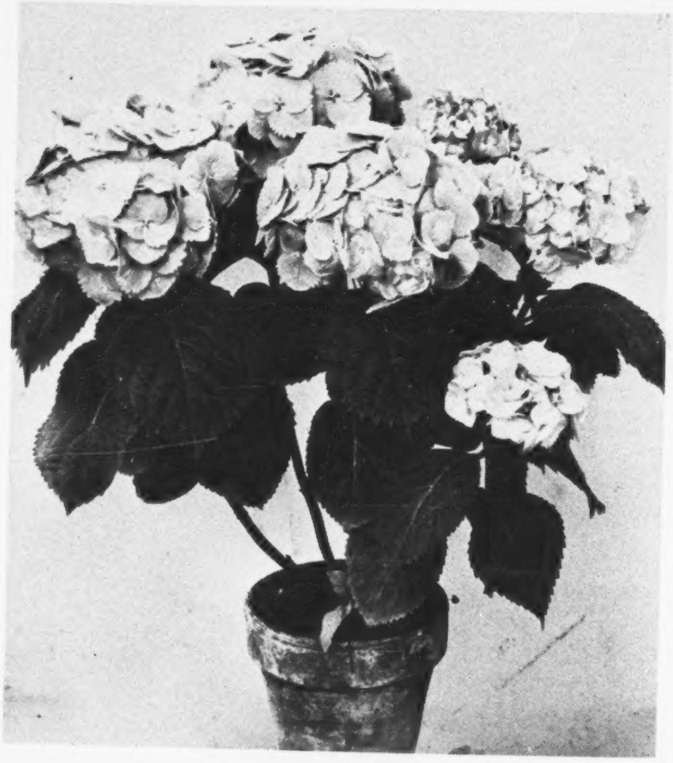


Figure 88. Hydrangea
(*Hydrangea macrophylla*)

Sales Period - Easter, Mother's Day

Propagation - purchase forcing size, dormant, precooled plants for forcing (for culture to this stage, see reference)

Pot Size - plant in next larger size than received -- usually into 6" standard

Soil - standard mixture; pH 6.5 for pink and white blooms, 5.0 for blue

Nutrition - 20-20-20 in irrigation system at 200 ppm N rate

Forcing Schedule - (1970 example - adjust for future years, see Appendices A and B)

Date	Development
December 2	remove from cold storage and place at 50°F
December 23	55°F, buds swelling
January 2	leaves unfolding
January 6	60°F, 2 - 4 leaves showing
January 10	6 leaves
January 15	8 - 10 leaves
January 21	flower head just visible
January 27	flower head dime size
February 3	flower head nickel size
February 9	flower head quarter size
February 16	flower head half-dollar size
February 27	flower head silver dollar size
March 2	bracts developing
March 5	bracts expanded
March 11	bracts coloring
March 16	bracts colored and hardening
March 25	harden at 50°F
March 29	Easter

120-day schedule for Strafford, Merveille and Engle's White; 10 days longer for Rose Supreme

Reference:

Commercial Flower Forcing, Seventh Edition. Reference No. 7.

POTTED PLANTS UNIT 5

African Violet

Figure 89. African Violet
(Saintpaulia ionantha)

Sales Period - mid-September through December; many sold year-around

Propagation - leaf petiole cuttings stuck 9 months before crop desired; air 65°F, medium 70°F; can be done under fluorescent lamps

Pot Size - 2-1/2" from propagation bench; shifted to 3" or 4" "azalea" in 4th month

Soil - 2 peat, 1 loam, 1 sand; pH 6.0 to 7.0; steamed soil

Light Intensity - 1500 fc. maximum; no shade in December, heavy shade on glass, plus muslin under glass in June

Temperature - 65°F

Nutrition - 10-30-30 in the irrigation water at 100 ppm N rate; or soluble every 14 days

Watering - must be kept moist at all times (wilt only under severe stress), water must be within 20°F of leaf temperature or cream blotches of killed chlorophyll will appear on foliage

Pests - cyclamen mites

Diseases - crown rot, powdery mildew, leaf spot, nematodes

Handling, Packing, Shipping - leaves are very brittle, plants are often allowed to wilt slightly to soften leaves so there is less breakage; must be well insulated in cold weather

Cultivars - Hundreds in the trade, new ones each year; customers want to buy labeled plants, so individual pots must be labeled with the cultivars; care cards are a good idea

Reference:

Commercial Flower Forcing, Seventh Edition, Reference No. 7.

POTTED PLANTS UNIT 5

Foliage Plants

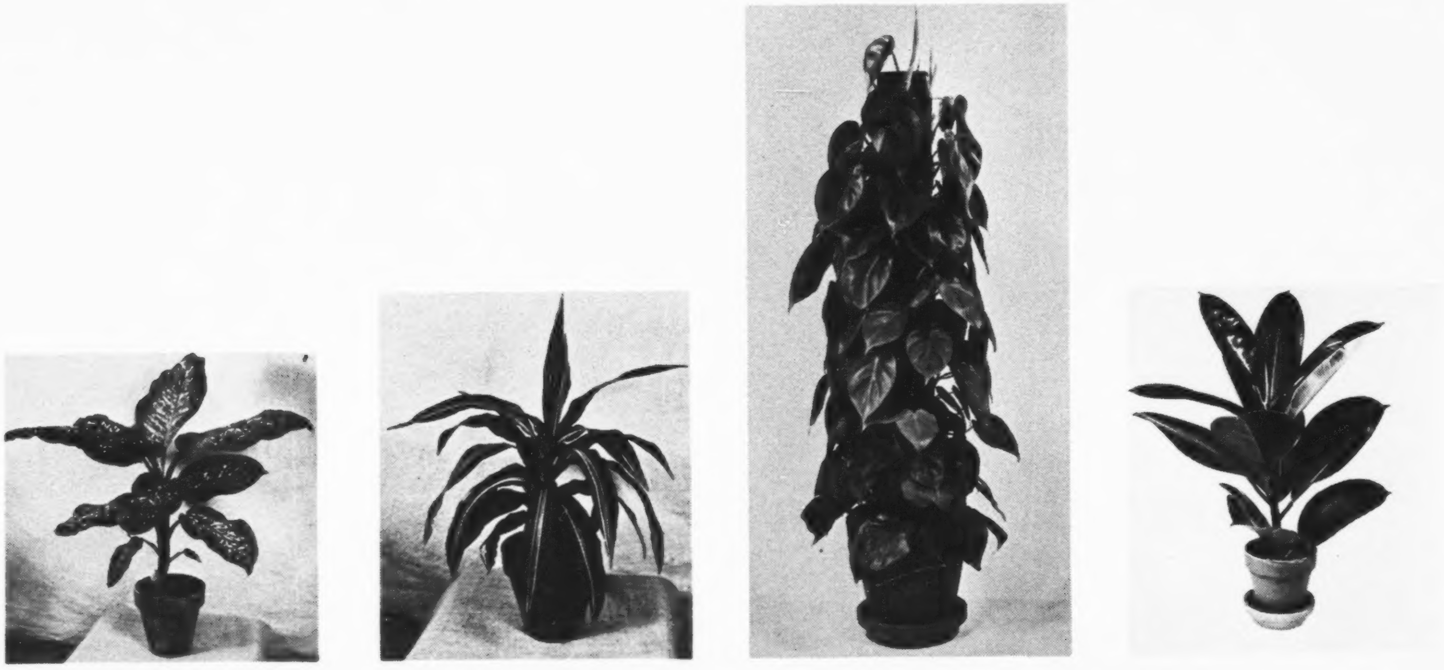


Figure 90. Foliage Plants, left to right, Dumb Cane (*Dieffenbachia picta*), Dracaena (*Dracaena sanderiana*), Philodendron (*Philodendron oxycardum*), Rubber Plant (*Ficus elastica* 'decora').

Sales Period - year-round, with the highest volume in fall

Kinds - several hundred cultivars of foliage plants for indoor use are commonly grown commercially

Propagation - most producers in the northeast United States purchase rooted cuttings or small plants for growing to salable size. Southern propagators use stem, leaf, or leaf-petiole cuttings or seed

Pot Size - varies with the kind and size of plant; "dish gardens" of mixed planting are often marketed

Soil - usually peat; some use 2 peat, 1 loam, 1 inert material

Light Intensity - 2000 fc. maximum from April 1 to October 15

Temperature - 65°F to 70°F for growing; 60°F to 65°F for holding; 75°F to 80°F for propagation

Nutrition - "constant feed" in irrigation water using 20-20-20 at 75 to 100 ppm N rate

pH - 5.5 to 6.5

Soluble Salts - below 80 "K"

Watering - except for cacti, intolerant of drying

Pests and Diseases - aphids, mealybugs, two-spotted mites, scales, root rots

Reference - *Exotica III*. Reference No. 13.

POTTED PLANTS UNIT 5

Spring-Flowering Bulbs

Figure 91. Spring-Flowering Bulbs: Tulip (Tulipa hybrid), Hyacinth (Hyacinthus orientalis), and Daffodil (Narcissus pseudo-narcissus). (Courtesy, Netherlands Flower Bulb Institute, New York, New York.)

Sales Period - Easter, but some sold February through April

Kinds - certain cultivars are superior to others for early, mid-season and late forcing. Appropriate ones should be ordered one year in advance of planting time

Pot Size - tulips - 5-inch, 3/4 pot; 6 bulbs
hyacinths - 5-inch, 3/4 pot, 4 bulbs; or 3-1/2-inch pot, 1 bulb
daffodils - 6-inch pot, 4 DN (double nose) bulbs

Soil - well drained, porous. Bulb tops should protrude slightly

Light - a light shade is needed for the first 2-3 days of forcing

Insects and Diseases - botrytis, leaf aphids, bulb aphids

Forcing Program Example - Easter 1970 (March 24)

Crop	Pot	Rooting Temperature	Start Forcing	Sell
Tulip	Nov. 15-30	3 wks. 48°F 4 wks. 41°F then 35°F	March 12 at 65°-68°F	March 24, 1970
Hyacinth	Nov. 15-Dec. 7	3 wks. 48°F then 35°F	March 12 at 65°-68°F	March 24, 1970
Daffodils	Nov. 15-Dec. 1	3 wks. 48°F 4-5 wks. 41°F then 35°F	March 6 at 60°F	March 24, 1970

References:

Using a Bulb Cellar. Reference No. 34.

Bulb Forcer's Handbook. Reference No. 5.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

There are many additional crops grown for sale by producers. Refer to references for detailed information concerning these crops and other popular plants.

Learning Resources

Supplies:

- Variety of pot sizes
- Cuttings
- Insecticides
- Fungicides
- Stakes and ties
- Growing medium
- Soluble fertilizer
- Forcing compartments
- Shade cloth
- Long-night lighting equipment

References:

The Penn State Geranium Manual, 1970. Reference No. 31.

1967 Cornell Recommendations for Commercial Floriculture Crops. Reference No. 10.

Commercial Flower Forcing, Seventh Edition. Reference No. 7.

Exotica III. Reference No. 13.

Audio-Visual Aids:

None

Suggested Learning Activities

1. Have students grow geranium "stock plants" and grow marketable size plants from cuttings.
2. Demonstrate the kinds of cuttings used for propagating foliage plants.
3. Demonstrate proper and improper forcing of bulbs.
4. Have students grow African violets from leaf petiole cuttings.

Test

1. How long in advance should producers order dormant rose plants?
2. What is meant by a "floribunda" rose?
3. At what temperature should geraniums be grown?
4. What is the recommended light intensity for geraniums?
5. What nutrient excess causes poor flowering of geraniums?
6. When is post-cooling used with potted plants?
7. What is the recommended pH for blue hydrangeas?
8. How are African violets propagated?
9. At what temperature should African violets be grown?
10. What growing medium is recommended for most kinds of foliage plants?

PROBLEM AREA 5

CUT FLOWER PRODUCTION

Because cut flowers are colorful living things, they have great appeal to many people. Although roses and carnations last 5 to 7 days, and chrysanthemums for 7 to 10 days, certain cut flowers, such as anthuriums and cymbidium orchids may last for as long as 3 to 4 weeks. Cut flowers are used for vase arrangements, corsages, weddings, and funerals.

Roses are the most popular cut flowers. They are also the most difficult to grow. Cut roses are grown by a relatively small number of specialists in large greenhouse ranges, usually covering several acres. Chrysanthemums are next in popularity, followed by carnations, gladiolus, snapdragons, and orchids. Spray type chrysanthemums and gladiolus are grown by specialists. The wholesale value of cut flowers in the United States is about 200 million dollars annually.

This Problem Area is divided into four Units: chrysanthemums, carnations, snapdragons, and a unit of single page recommendations for roses and orchids.

CUT FLOWER UNIT 1

Chrysanthemum
(Chrysanthemum morifolium)

Learning Objectives

1. To learn how to prepare a full year rotation plan for cut chrysanthemums.
2. To know the proper preparation of the soil used for chrysanthemums.
3. To learn the proper method of planting rooted chrysanthemum cuttings.
4. To learn the other cultural requirements of chrysanthemums: temperature control, carbon dioxide requirement, pinching, and watering.
5. To learn how to prepare chrysanthemums for the market - harvesting, grading, bunching, and packing.

Key Questions

1. How do potted chrysanthemums differ from cut chrysanthemums?
2. What are the four groups of cut flower chrysanthemums? How do they differ from each other?
3. What kind of soil is good for growing chrysanthemums? How is it prepared for use in the bench or bed?
4. When planting, does spacing of the cuttings have an effect on the crop produced? In general, what is the best spacing of the plants?
5. When and how are chrysanthemums watered?
6. Why is temperature control important in growing cut flower chrysanthemums?
7. What is the value of carbon dioxide in the production of chrysanthemums?
8. Why is pinching of chrysanthemums necessary? How is it done?
9. Describe how chrysanthemums are prepared for market - harvesting, grading, bunching, and packing.

New Words

Bacteria - disease-producing microorganisms

Bench - an area where cut flower plants are placed for growing. If it rests on the floor of the greenhouse it is called a bed.

Fungi - microscopic, disease-producing plants

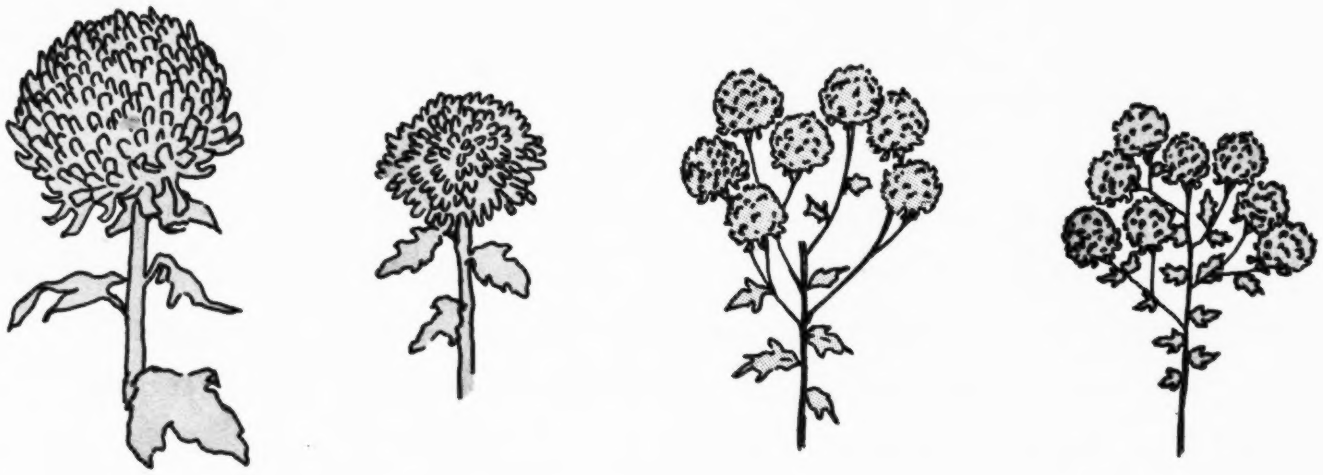
Lateral Buds - buds on the side of the stem

Terminal Bud - the bud at the top of the stem

The production of chrysanthemums as a cut flower crop closely parallels its production as a flowering pot plant. Many of the operations are the same in each case. For information concerning types, propagation, temperature control, and photoperiod control the student should refer to Problem Area 4 , page 69.

The crops do differ in some respects. The compact nature desirable in potted chrysanthemums is not desired in cut flower crops. Potted chrysanthemums are grown with short stems (8 - 12 inches), whereas, cut chrysanthemums are encouraged to produce plants with much longer stems (about 30 inches). In order to produce these longer stems, cut chrysanthemums are grown vegetatively for a longer period of time before flowers are allowed to set.

The four groups of cut flower chrysanthemums are illustrated in Figure 92. "Fast crop" chrysanthemums and disbuds are grown with stems about 18 inches long and, therefore, require shorter forcing schedules. Details on "fast crop" chrysanthemums are given in "Ball Mums," Reference No. 3, page 31.



Standard Disbud Disspray Spray

Figure 92. Cut flower chrysanthemums:

Standard - any large-flowered type, all lateral flower buds removed
Disbud - any spray-type grown with all lateral flower buds removed
Disspray - any spray-type with the central flower bud removed to improve the spray formation
Spray - any spray-type (pompon, anemone, decorative daisy, spider, fujii, spoon) grown without removal of any flower buds

Rotations

Cut flower chrysanthemums require about four months to flower. A "no pinch" crop requires slightly less time. By combining one "no pinch" crop with two pinched crops, a greenhouse manager can run a cycle of three complete crops in one year.

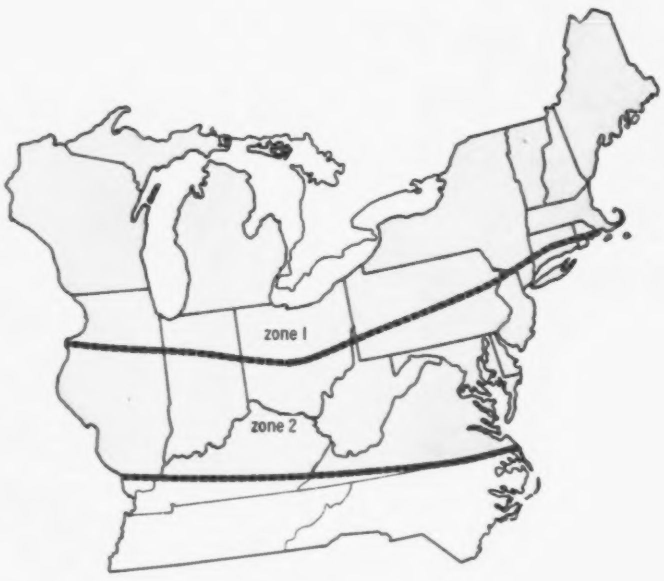


Figure 93. Cut flower chrysanthemum zones 1 and 2 for northeastern United States. (Adapted from Ball Mums, Tech. Bul. 310)

Because day length changes occur differently in different latitudes (day lengths change more rapidly and more extremely in northern latitudes), photoperiodic crops, such as chrysanthemums, must be handled with slight differences in northern and southern United States. In northeastern United States, chrysanthemums have been found to respond slightly different in the two zones. Forcing schedules are therefore slightly different for these two zones. Table 12 illustrates year around schedules for zones 1 and 2. Note that one crop is aimed for Christmas. Figure 93 shows chrysanthemum forcing zones 1 and 2.

Bench Preparation

The success of an entire chrysanthemum crop depends on the proper preparation of soil used in the bench or bed. When new benches are being filled, outdoor field soil is used. Any soil that has been growing good crops can be reused after adding humus and steaming. A coarse, porous soil is preferred.

No matter what kind of soil is used, steam sterilization is necessary to kill harmful fungi and bacteria in the soil. Steaming also improves soil structure, kills weeds and weed seeds.

A problem of steaming previously used soil is that toxic quantities of ammonia may be produced. Chrysanthemums are easily injured by ammonia. If ammonia odors are detected, broadcast 5 pounds of gypsum or superphosphate per 100 square feet of soil. Follow immediately with water.

Table 12. One-Year Rotation Plans for Cut Chrysanthemums in Zone 1 and Zone 2*

	Planting Date	Pinching Date	Lighting Period	Start Shade	Stop Shade	Response Group	Flowering Date
ZONE 1							
Pompons	Aug. 16	Aug. 30	Aug. 16-Sept. 19	Sept. 20	Oct. 20	13	Dec. 20
Standards	Aug. 16	Aug. 30	Aug. 30-Oct. 10	NO	- - -	10	Dec. 20
(Unpinched Crop)	Dec. 27	Note B	Dec. 27-Feb. 20	March 15	Note A	10	April 17
Pompons or Standards	April 24	May 8	April 24-May 28	May 29	Note A	10	Aug. 7
ZONE 2							
Pompons	Aug. 23	Sept. 6	Aug. 23-Sept. 12	Sept. 13	Oct. 20	13	Dec. 20
Standards	Aug. 23	Sept. 6	Aug. 23-Oct. 10	NO	- - -	10	Dec. 20
Pompons or Standards	Dec. 27	Jan. 24	Dec. 27-Feb. 20	March 15	Note A	10	May 1
Pompons or Standards	May 1	May 15	May 1-June 4	June 5	Note A	10	Aug. 14

*Source: Ball Mums, Technical Bulletin No. 310, George J. Ball, Inc., West Chicago, Illinois.

NOTES:

A Stop shade for spray types when buds show color; stop shade for standards flowering October-May when bud is size of nickel; stop shade for standards flowering June-September when disbudding is done.

B For single stem crops, plant cuttings on pinching date.

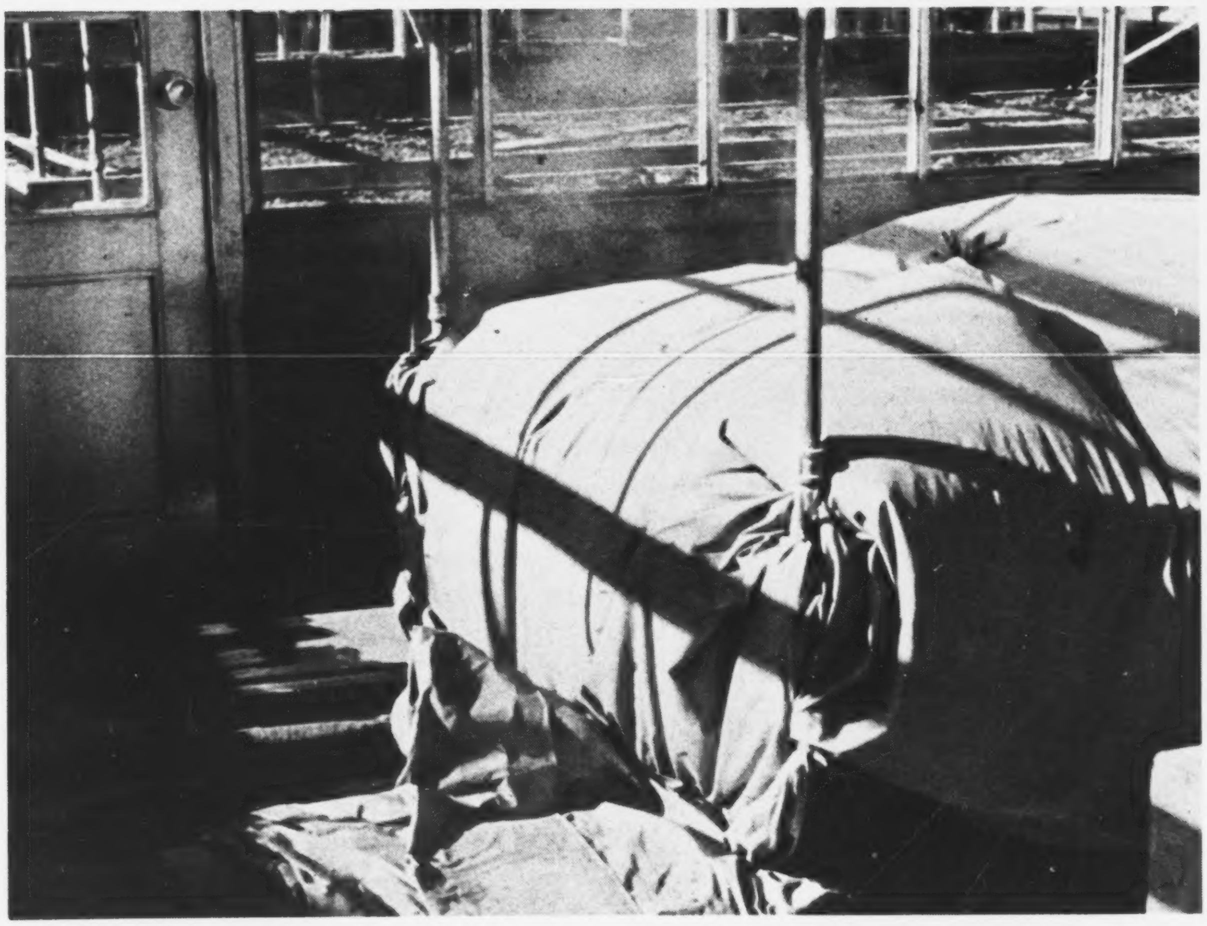


Figure 94. Steam sterilization is the safest and most effective method for sterilizing soil mediums.

Planting

Chrysanthemums are planted in the bench or bed as rooted cuttings. They should be spaced so as to produce the quality and quantity of flowers that can be sold for the most profit. Generally speaking, a spacing of 7 by 8 inches is used for plants that will be pinched, and 4 by 6 inches for plants that will be grown as single stems.

The spacing of the cuttings has a major effect on the crop produced. Size of bloom, spray form, weight, and strength of stem are greatly affected by spacing. Squeezing the plants together will produce small, weak flowers; too much space is uneconomical. The spacing required per stem is related to the height of the crop. Tall crops need wider spacing, while short crops do well with less space per stem. Recommended spacings for pompons, standards, and fast disbuds, under reasonably favorable conditions, are given in Table 13.

Table 13. Recommended spacing for year-round flowering of pompons, standards, and fast disbuds*

Single Stem	Crop to Flower	Spacing
Pompons	April 15 - November 1	4 x 6 in.
	November 1 - April 15	4 x 7 in.
Standards	April 15 - November 1	5 x 6 in.
	November 1 - April 15	6 x 6 in.
Disbuds and Fast Crops	April 15 - November 1	4 x 6 in.
	November 1 - April 15	4 x 7 in.
Pinched		
Pompons	April 15 - November 1	7 x 7 in.
	November 1 - April 15	7 x 8 in.
Standards	April 15 - November 1	7 x 8 in.
	November 1 - April 15	8 x 8 in.
Disbuds and Fast Crops	April 15 - November 1	7 x 7 in.
	November 1 - April 15	7 x 8 in.

*Source: Ball Mums, Technical Bulletin No. 310. Reference No. 3.

Three things should be kept in mind when planting rooted chrysanthemum cuttings: (1) keep water loss to a minimum by misting the plants often enough to keep the leaves moist, (2) aid root growth by planting shallow so that the soil around the plant has an adequate air supply, and (3) apply an appropriate amount of nitrogen to maintain good leaf color.

Watering

Growers face a difficult problem in watering chrysanthemums. Knowing when and how to water is a difficult art. Only after long study and experience with his particular soil, his crops at various stages, and his climate can a grower feel fairly confident when it comes to watering chrysanthemums. Chrysanthemums have what is probably the highest water requirement of any commercial cut flower crop. During very hot weather they are sometimes watered twice a day.

Newly planted cuttings require very little water, yet, the demand increases rapidly as the plants begin to grow. Due to this high demand for water the grower should carefully select a soil that drains well in order to prevent waterlogging.

As chrysanthemums mature, the demand for water decreases. The water demand especially decreases as the buds begin to swell. However, excessive dryness at this time can cause a decrease in flower size.

A semiautomatic watering system is very useful when growing chrysanthemums. A fertilizer injector can be used with the system to allow the grower to fertilize the plants while watering. A good rule-of-thumb in watering is to apply one gallon of water per 2 square feet of area 6 inches deep. This usually provides enough water to leach soluble salts from the soil.

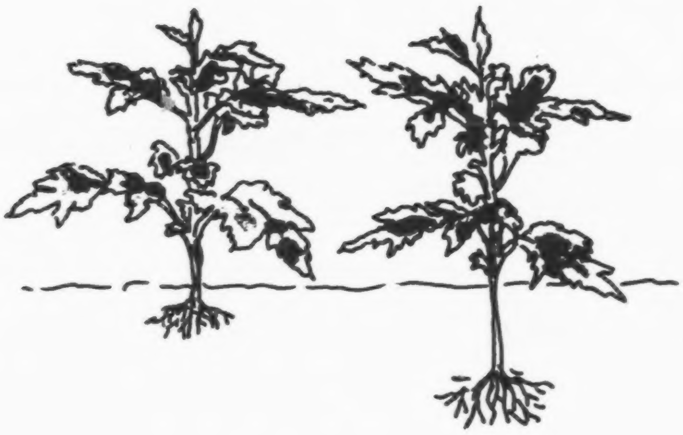


Figure 95. Correct planting depth for chrysanthemum shown above, left.

Fertilizing

Cut flower chrysanthemums are usually fertilized with a 20-20-20 soluble fertilizer at a 200 ppm N rate in the irrigation water. After the time when buds show color, a 12-0-43 fertilizer at a 200 ppm N rate is used. This higher level of K gives better quality blooms.

Temperature

Cut flower chrysanthemums should be started at 62° to 65°F night temperature. About 2 weeks after short days are started, this can be lowered to 60° to 62°F. Temperatures lower than 60°F may prevent flower buds from forming. Day (or night) temperatures above 80°F also prevent or greatly delay flower bud formation and development.

Fall crops should be finished at 56° to 58°F to intensify color.

From mid-March to mid-September standards should have a cheese cloth shade stretched over them from the time they begin to show color until they are harvested. Failure to do this will result in sun scorch of the petals (which looks like an attack of botrytis) which makes the flowers unmarketable.

Carbon Dioxide

Carbon dioxide used at 1200 ppm results in improved flower size and quality. The forcing time will also be shortened. When carbon dioxide is used, the plants may require more fertilizer, and the day temperature should be allowed to go 5°F higher than the normal range in the daytime.

Pinching

Chrysanthemums are pinched in order to produce a branched plant. Pinching is one of the methods used to force chrysanthemums to produce the desired quality flower at the right time. A soft pinch should be used.

After pinching, several shoots develop. These shoots should be pruned to produce the desired number of stems. Usually, two shoots are left to flower except on outside rows where light conditions permit growing three stems.

Properly grown cut flower chrysanthemums will have stems that are strong enough to support the flowers without breaking but soft enough to readily absorb water.

Grading and Bunching

Grading and bunching are not standardized for this crop. Each chrysanthemum producer must use his own judgment. Usually, spray types are bunched in 9 oz. bunches of five or more stems per bunch. Standards are graded by size of flower. Disbuds are graded by size of flower and length of stem.

Although not universally accepted, the Society of American Florists has a set of standards for grading standard chrysanthemums as shown in Table 14.

Table 14. Society of American Florists Standard Chrysanthemum Grades.

	Blue Grade	Red Grade	Green Grade	Yellow Grade
Minimum flower Diameter	5-1/2 inch	4-3/4 inch	4 inch	3-1/4 inch
Minimum stem Length	30 inch	30 inch	24 inch	18 inch

Inspection Standards:

1. Similar varietal characteristics
2. Bright, clean, and not badly wilted flowers and leaves

3. Normal shape of flowers for the kind of variety and placed approximately at right angle to the stem
4. Fairly tight -- with center "petals" unopened and not exposing the center of the flower
5. Free of injury, defect, dirt, or other foreign materials; discoloration, insects, diseases, or nutritional chemical or mechanical abnormality which affects the appearance or shipping quality
6. Fairly straight, stiff stems capable of supporting the flower in an upright position
7. Foliage should be stripped from not more than the lower one-third of the stem

The Society of American Florists has no standards for pompons. North Central grade standards as shown in Table 15, can be used as a guide.

Table 15. North Central Pompon Grade Standards.

GRADE NAME	LABEL COLOR	FLOWERS PER STEM	MINIMUM STEM LENGTH
U.S. Extra Fancy	Purple	9	30 inch
U.S. Fancy	Blue	7	25 inch
U.S. No. 1	Red	5	20 inch
U.S. Design	Green	3	15 inch

These flowers should also meet an inspection standard similar to those shown under S.A.F. Standards.

Packing

Standards are the most difficult to pack with a minimum of damage. A cushion of rolled newspaper is placed on the bottom of the box and the flowers are laid with the neck resting on the newspaper. The next row is laid with the heads resting on the neck of those below. This "shingling" is continued, with paper between each layer, until the box is full.

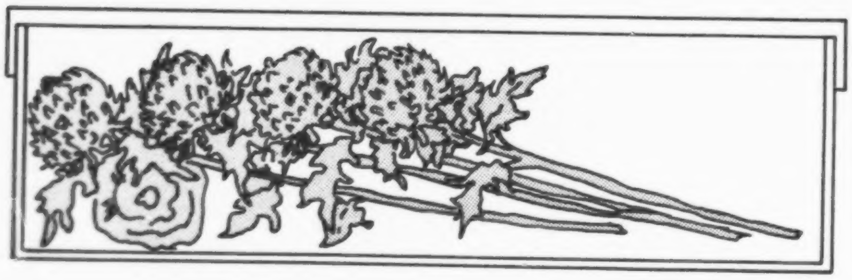


Figure 96. Standard chrysanthemums packed for shipping.

Bunches of the spray types are placed in the box side-by-side, layer-on-layer until the box is full.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Learning Resources

Supplies:

Rooted cuttings of cut flower chrysanthemums
Commercial catalogs
Black shade cloth
Long-night, lighting equipment

References:

Ball Mums, Technical Bulletin No. 310, Reference No. 3.
Chrysanthemums, A Manual of the Culture, Diseases, Insects, and Economics of Chrysanthemums. Reference No. 6.
Commercial Flower Forcing, Seventh Edition. Reference No. 7.
Flower and Plant Production. Reference No. 15
1968 Gloeckner Chrysanthemum Manual. Reference No. 17.

Suggested Learning Activities

1. Have the class visit a greenhouse and do the following:
    a. Request the greenhouse grower to demonstrate the proper preparation of the soil used in the bench or bed for growing cut flower chrysanthemum.
    b. If it is possible, have the class observe pinched and unpinched chrysanthemum crops.
    c. Have the class observe the grading, bunching, and packing of cut flower chrysanthemum.
2. Using catalogs and the table in the text as guides, have the class work out a one-year rotation plan for cut chrysanthemum production.
3. Have the class plant chrysanthemums in the school greenhouse; use correct spacing and watering.

Test

1. Normally, how long will it take a cut flower chrysanthemum to bear flowers?
2. How can one produce a cycle of three complete crops of cut flower chrysanthemums in one year?
3. Why is it important to sterilize the soil before planting?
4. If toxic quantities of ammonia odor are detected after steaming, what problem is present, and how is it eliminated?

5. What are the three important things to remember in planting rooted cuttings of chrysanthemum?
6. How frequently should cut flower chrysanthemum be watered in very hot weather?
7. When packing, how should the flowers be arranged inside the box?
8. How are the standard types of chrysanthemum flowers graded? Spray types? Disbud types?
9. What is the result of pinching chrysanthemums?
10. At what temperature should a greenhouse be maintained for cut flower chrysanthemum production?

CUT FLOWER UNIT 2

Carnation

(*Dianthus caryophyllus*)

Learning Objectives

1. To learn the planting schedule of carnations.
2. To learn how to propagate and plant carnations.
3. To learn how to control light and temperature in the culture of carnations.
4. To know the advantage of pinching carnations and how it is done.
5. To learn how to harvest, grade, pack, and market carnations.

Key Questions

1. How are carnations propagated?
2. What is the advantage and disadvantage of pruning the leaves?
3. What is the best way of planting carnations?
4. Of what use are wires and grids to the plant?
5. What is the best day and night temperature for carnations?
6. Is disbudding necessary? Why?

New Words

Bunched - grouping together things of the same kind

Grids - a framework of metal bars or wires

Pruning - cutting the leaves, branches or vines

Reset - a plant that is planted again

Shoots - new growth in plants

Sport - a change in color or shape of a plant part, that can be reproduced vegetatively

Terminal cuttings - cuttings at the end or top of a stem or branch

Cultivars

Most of the carnations in cultivation are sports of William Sim, a red variety introduced in the U. S. about 20 years ago. These sports are tall growing, with large blooms, well adapted to most climates, and are very productive. Sydney Littlefield is large-flowered, and a number of good sports of it have been introduced. They do, however, have shorter stems than the Sim sports and are less productive.

In most marketing areas the demand is for about 30 to 40% white. Many white ones are tinted upon request of the retailers for unusual colors. Light pink comes next in popularity at around 30%. At Christmas, Valentine's Day, and Mother's Day, red is very popular. Some growers plant from 20 to 25% red. A maximum of 20% is made up of yellow, multi-colors, and novelties. Miniatures have been steadily increasing in popularity.

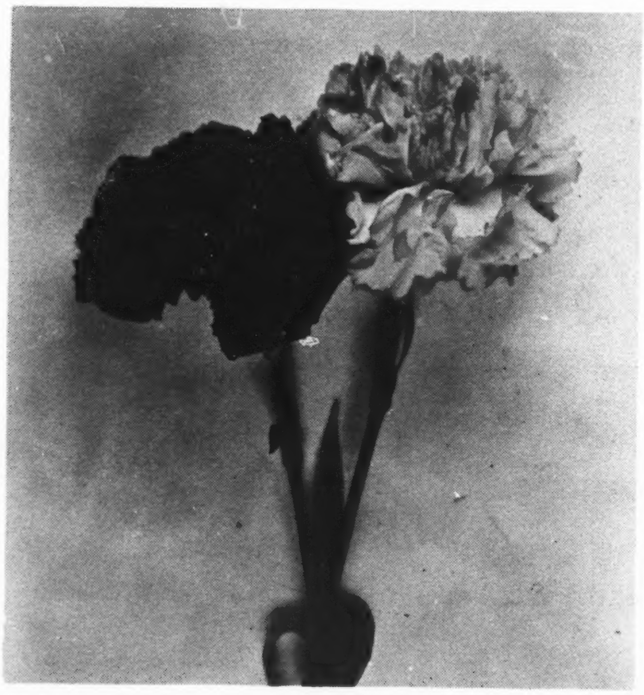


Figure 97. Standard carnation.

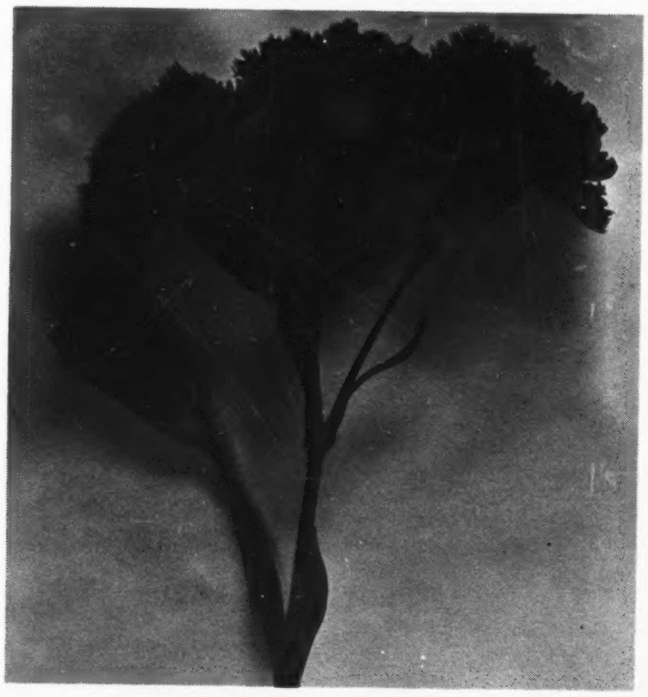


Figure 98. Miniature, or spray-type carnation.

Spray type, or miniature, carnations with from 5 to 8 small blooms per plant are increasing in popularity.

Each year a number of new cultivars are introduced, and older, inferior ones are discarded. Wholesale florist's catalogs give illustrations and descriptions of cultivars currently in use.

Rotations

Although carnations produce flowers continuously, once they start to flower, the producer has to produce large quantities for holidays as well as a steady supply throughout the year. The greenhouse manager also has to replace the plants once a year or once every 2 years. Replacement of plantings must be done in succession so that carnations are harvested throughout the year.

Some examples of planting schemes are shown in Figure 100, page 165.

Propagation

Carnations are propagated from terminal cuttings. Terminal cuttings are taken from stock plants grown especially for propagation purposes. The stock plants are usually flowered once to check for trueness to type, and from that time on they are pinched regularly to encourage production of many shoots. The stock plants must be properly fertilized and watered to produce large, vigorous cuttings. Cuttings are broken out and stuck in sand.

Carnation cuttings will form roots in about 10 to 14 days when they have been stuck in a propagation bench equipped with a misting system.

Most carnation growers order rooted cuttings from propagation specialists, specifying the exact date they want delivery. Such orders are usually placed many months in advance of the planting date.

Soil and Fertilizer

Carnations are grown in benches in the same soil mixture as cut flower chrysanthemums as described on page 153.

Many carnation growers are using "constant feed" in the irrigation system as described for chrysanthemums on page 157. For carnations a 20-5-30 analysis fertilizer at a 200 ppm N rate is often used; see page 51. Single "booster" applications at a 400 ppm N rate should be made at the time of growth spurts in spring and fall.

Many carnation growers determine the nutrient level of the soil every month, including pH. The Department of Floriculture at Cornell University recommends the following levels and stresses the fact that organic fertilizer should not be used because of slow breakdown and release of nutrients at soil temperatures near 50^{o}F.

NO_3	25-60 ppm
P	4-6 ppm
K	25-50 ppm
Ca	Over 100 ppm (150 ppm for miniatures)
pH	5.5 to 7.0
Soluble Salts	less than 150 MHOS (measure of conductance)

Planting

Shallow planting of carnations will develop rapid root growth and give the young plants a faster start. The upper roots should be barely covered with soil. This also aids in the prevention of stem rot. The plants should be set so shallow that a number of them are likely to topple during the first watering and need to be reset.

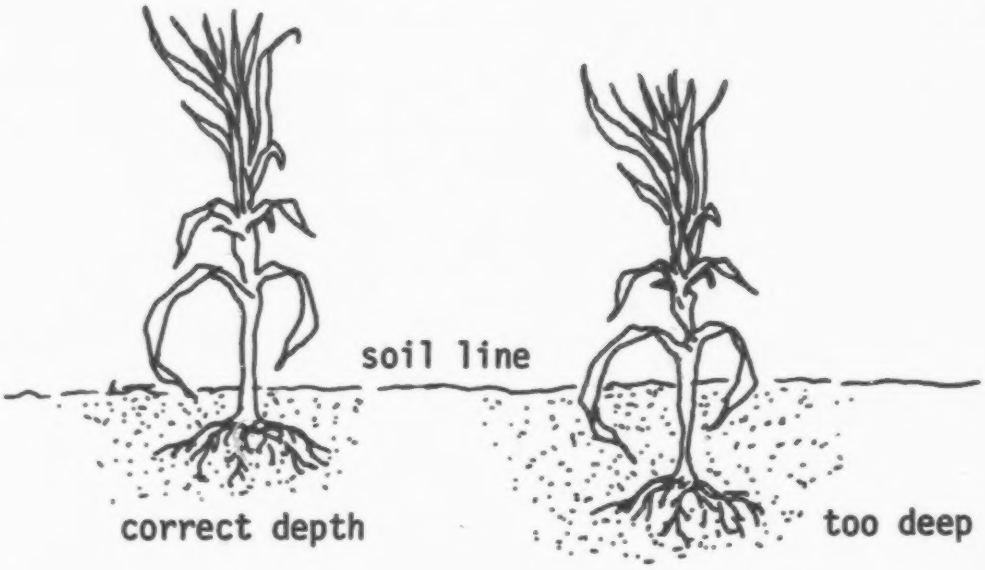
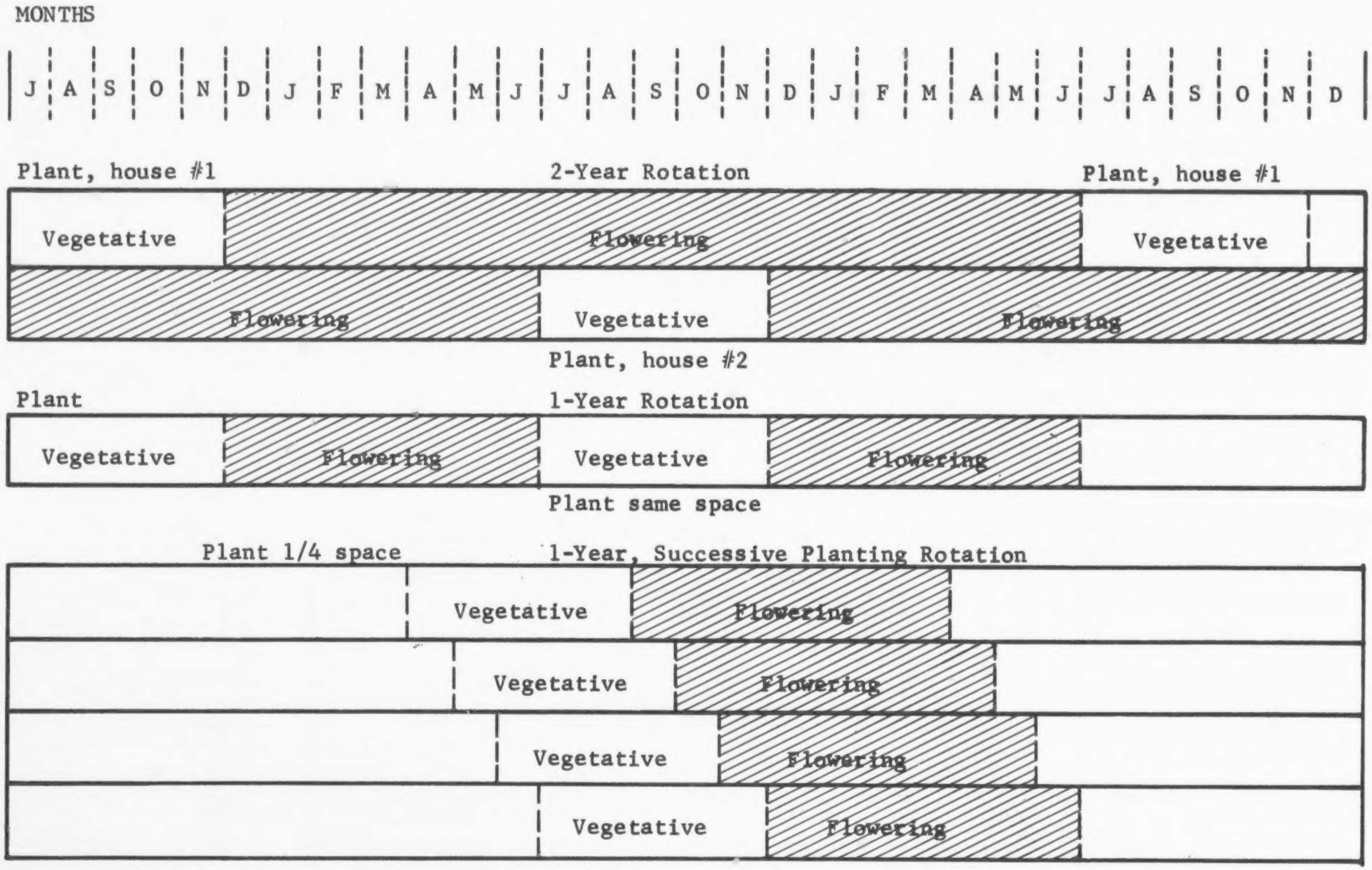


Figure 99. Correct planting depth for carnations. (Adapted from Grower Circle No. 67, October, 1968, Yoder Brothers, Inc.)


MONTHS
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
Plant, house #1
2-Year Rotation
Plant, house #1
Vegetative
Flowering
Vegetative
Flowering
Vegetative
Flowering
Plant, house #2
Plant
1-Year Rotation
Vegetative
Flowering
Vegetative
Flowering
Plant same space
Plant 1/4 space
1-Year, Successive Planting Rotation
Vegetative
Flowering
Vegetative
Flowering
Vegetative
Flowering
Vegetative
Flowering

4 to 6 week harvest peak from a pinch, and second harvest peak from the same pinch.

Figure 100. Carnation rotation schemes

The plants in the bench should be spaced 6 by 8 inches. Closer spacing of 6 by 6 inches may be used for a crop to be pinched only once. Double row planting makes operations like cutting of flowers, irrigation and fertilization easier. It also results in improved air circulation and better lighting for the plants at the middle. In a double row planting, two rows of plants are set 4 inches apart between rows and 6 inches apart within the row. A space of 12 inches is left between rows. The total number of plants in the bench is the same as for a 6 x 8 inch spacing.

The stems should be supported with layers of wire and string, or wire grids. The first grid is placed 6 inches above the soil, and the succeeding grids are gradually spaced until the top ones are 12 inches apart. If wire and string grids are used, wire is strung the length of the bench between the plants, and string is placed across the bench beside each row of plants. If grids are added, upright columns are formed for the support of each plant. Welded wire fabric with 6 x 8 inch spacing may also be used. If this is used one or more of the grids are placed on the soil, and planting is done through them. The grids are raised as the plants grow.

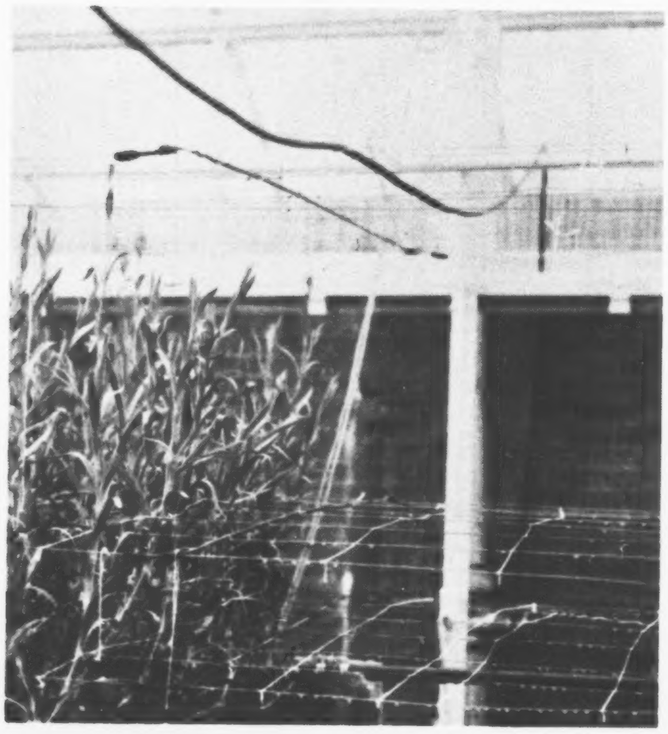


Figure 101. Supports of wire and string for a carnation crop.

The wires must be stretched tightly, well anchored, and the grids must be supported about every 12 feet down the bench with metal or wood.

Temperature Control

Carnations grow and flower best when the night temperature is near 50°F. Carnation "splits," a disorder in which the calyx splits vertically and allows petals to hang out (an inherited trait of some cultivars) is caused by wide differences between day and night temperatures. For this reason, the variation between night and day temperatures should be held within a 15°F range. See Figure 102, p. 168.

During spring, summer, and fall the "ideal" night temperature of 50°F is not possible. During those months the night temperature is "floated" about 10° to 15°F below the prevailing day temperature. At these times, a greenhouse manager makes an effort to have no more than a 2°F change in night temperature in a 48-hour period. During exceptionally cool nights in spring and fall he may have to "run a little extra heat" to avoid a temperature gap that would give a poor quality crop.

One of the most valuable developments for the carnation grower is summer cooling. Evaporative cooling during midday can be used where summer humidities are not excessive. Too much heat hardens the plants, delays growth, and reduces quality of flowers.

Another aspect of temperature control involves winter ventilation. Too much cold air and sudden chilling of flower buds will cause whorls of petals, leading to bull-headed flowers or split calyxes. Carnations grow best in an environment where there is a gradual change of temperature.

Guide for temperature control of carnations:

	Summer	Fall	Winter	Spring
Day	70°F	65°F	60°F	65°F
Night	60-65°F	55°F	48-50°F	55°F

Light Intensity Control

In the low light period of the winter months it is important that carnations receive all the light possible. Even a light film on the greenhouse glass can cut the light by 50%. For this reason, many greenhouse managers wash the greenhouse glass in late fall and again in mid-winter if weather allows them to do so.

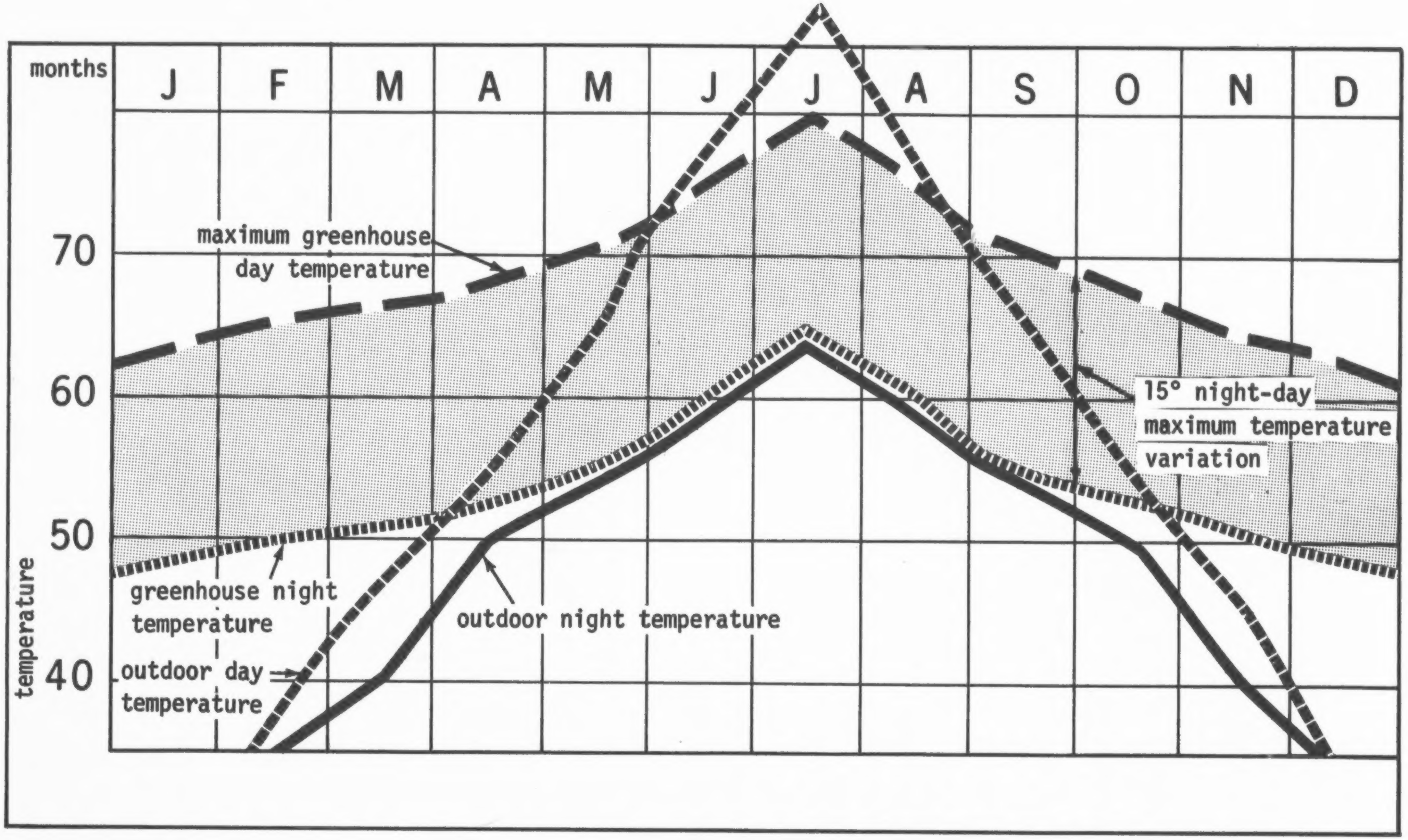


Figure 102. Range of night to day temperatures for carnations should not exceed 15°F. In winter, the day temperature is "floated" above the night temperature of 48° to 50°F. In late spring, summer, and early fall the night temperature is "floated" under the day temperature. (This chart is based on the presumption that evaporative air cooling is being used.)

Because midsummer light is more intense than needed by the plants, and shading will help hold down temperatures, carnations are usually given a light shade during late spring and all summer. For details on shading greenhouses see page 32.

Photoperiod Control

Carnations will flower about 20 days earlier and produce about 19 blooms per sq. ft. (instead of 15) in a 6 week peak crop period, if they are given a short-night treatment combined with an increase in CO_2 levels. This beneficial effect is obtained by giving artificial light for a six-week period, beginning at the time the plants are given a pinch. Best results are obtained by lighting for 6 hours in the middle of the night using 40 watt incandescent lamps 3 feet above the soil level and 18 inches apart (to give 15 fc). The months when this treatment is effective are August through March.

Carbon Dioxide

The photoperiod control explained in the previous section must be combined with increased CO_2 daytime levels during dull winter weather to get the maximum crop improvement. The CO_2 level should be at 1000 to 1500 ppm as explained in Problem Area 2, page 28 . Only if the CO_2 level is raised, can the night temperature also be raised to 55°F.

Pinching

Carnations are pinched to induce branching. In a few instances in which a closely-planted (4 x 4") crop is aimed to give a first "cut" at a specific holiday, such as Mother's Day, carnations are grown without a pinch.

Carnations are ready for the first pinch 3 to 4 weeks after planting. The determining factor is the speed of lateral growth. Once the side shoots in the leaf axils have "freed themselves" (the first "joint" or node is visible) the main shoot should be pinched. This is done by removing the top, leaving from 4 to 6 pairs of leaves. See Figure 103, page 170.

About 5 weeks after the first pinch is made, the laterals are ready to be pinched. This is referred to as the "second pinch." The laterals are pinched in the same manner as the original shoot was pinched. Usually only 1/2 of the total laterals are pinched. This allows unpinched laterals to produce blooms earlier than the pinched ones, thus giving flower production over a longer period. A "solid second pinch" is given if the crop is aimed to peak for a holiday.

A flower is harvested from a shoot about 5 months after the shoot has been pinched.

October flowers come from shoots that were pinched in June. Shoots pinched in July flower 5 to 6 months later. Spraying with Fermate, Zerlate,or similar material after pinching is a good practice for controlling diseases.

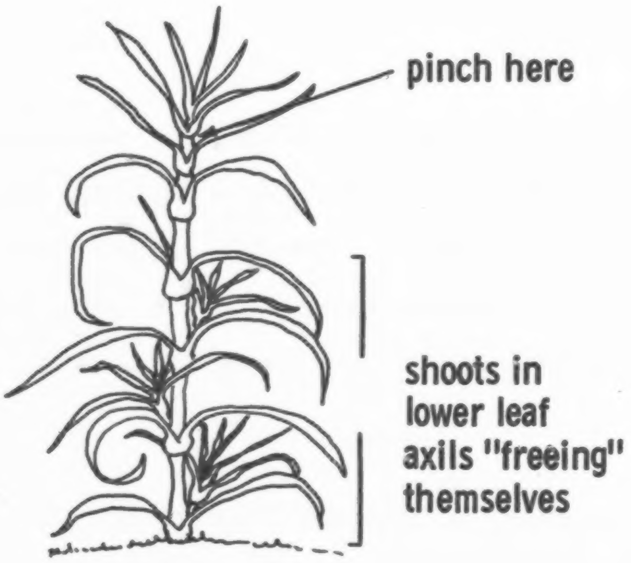


Figure 103. The right stage of growth for the first pinch.

Disbudding

Excess flower buds that form along each carnation stem are removed as soon as they are large enough to be broken out. The largest one on the top, or terminal bud, is allowed to flower. Excess buds are removed by bending the bud at right angle to the stem and twisting slightly. Disbudding is done as soon as the buds can be handled. If they are left on too long, the size of the terminal flower decreases. The leaves should not be torn or removed during disbudding because this damage lowers the quality of the flower. The three to four buds below the top bud are removed. The lowest 3 or 4 leafy shoots are allowed to remain because they produce the next flower crop. Spray type carnations are neither pinched nor disbudded, however, they are allowed to develop naturally to produce 5 to 8 blooms on a branched stem.

Pest Control

The most serious pest of carnations is the two-spotted mite. In spring when the weather is warm, they multiply rapidly. The attacks on the plants are very serious in summer and fall because of high temperatures. The leaves of the infested plants dry up leaving the plant worthless. This mite is controlled by applications of systemics in the soil such as Meta-Systox-R and by sprays such as Pentac. Before using any pesticides, read the WARNING on page 65.

A pest that causes streaks in the flowers during warm weather is thrips. Flowers affected are unmarketable. To reduce the thrips population, side vents should be screened. The vents are covered with cloth soaked or sprayed with dieldrin. Dusting or spraying at regular intervals is also essential.

Aphids or plant lice disfigure the young growth and cripple it severely. They are controlled by Vapona applied as smokes, aerosols or sprays.

Diseases

Rhizoctonia stem rot - This disease causes rotting of the tissues starting at the surface of the stem at the soil line and proceeding to the inner portions. A moist environment and low termperatures enhance the rapid development of stem rot. Sterilizing the soil eliminates this soil-borne organism that causes this disease. Shallow planting and allowing the soil to dry between watering help in minimizing the disease. If infection occurs, apply a fungicide such as Morsodren or Terraclor to the area.

Fusarium wilt - This disease is caused by a fungus which grows in the water-conducting tissues of the stem. Rapid infection occurs during hot weather. The best way to control this planting disease-free cuttings, and thorough sterilization of the soil, benches and equipment.

Botrytis blight - The symptom of the disease is the appearance of a water-soaked petal which later develops a gray mold. The mold grows best in a humid atmosphere. A gentle air movement must be provided in carnation greenhouses at all times to prevent the spread and to control the disease.

Fusarium rot - This is a fungus disease usually found in the propagation bench or among the young plants. The organism may be introduced into a planting on the surface of cuttings,or it may be soil borne. The best means of control are soil sterilization and careful watering practices.

For further details on control of pests of carnations, see Reference No. 10, 1967 Cornell Recommendations for Floriculture Crop, Reference No. 26. P.S.U., and Reference No. 16, P.S.U.

Harvesting the Flowers

It is important to cut carnations at the correct stage. The center petals should be extended forming a hemisphere. If they are harvested too "tight," the blooms may fail to open. Growers can usually cut blossoms tighter in the summer time and still have them open properly. The blossoms develop rather slowly and growers can usually cut only three times a week except in warmer weather when they often cut daily. The flowers are not actually cut, but snapped off at a joint (or node). This is done because certain diseases can be rapidly spread from diseased to healthy plants when a knife is used. The stems are carried in one hand while the flowers are harvested with the other. The stems are always removed so that the longest possible stem is obtained without harmfully affecting the plant and the next crop. During the fall, a stem portion with 3 to 4 developing laterals is left on the plant so a rapid return crop will follow.

Grading

Most carnations are cut in the morning, graded, bunched, and placed in vases in a 40°F refrigerator.

One grading standard used is to select 25 flowers of the same quality of a variety per bunch. Culls, splits, or shorts are discarded or sold as work or utility flowers.

A set of S.A.F. (Society of American Florists) grades that are gaining acceptance are shown in Table 16.

Table 16. Society of American Florists Standard Carnation Grades

Grade	Minimum flower diameter in inches	Minimum stem length in inches
Blue	2-3/4, up	22
Red	2-1/4	17
Green	any	10
White	all "splits"	

Flowers in all grades must be free from blemishes and have straight, strong stems.

"Sleepy" carnations are unmarketable. They are carnations that have petals that are full size but never open outward. Exposure to very minute quantities of illuminating gas, far below levels at which one can detect an odor, are a cause. Harvesting carnations too early may also cause them to be "sleepy."

Bunching, Packing, and Storage

A bunch has 25 flowers. They are packed with all heads together and the stems are tied with a string. The flat pack on a cardboard holder is preferred over the round bunch because it reduces stem breakage. If a cardboard holder is not used,the heads are held together with a string. A piece of tissue paper around each bunch prevents the heads from breaking.

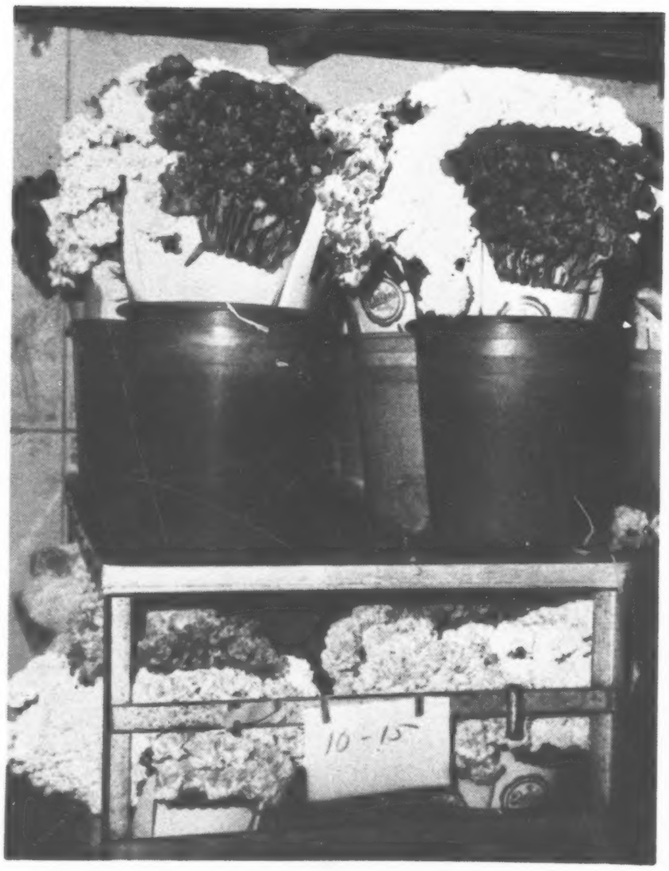


Figure 104. "Flat pack" carnations in water in a refrigerator at a greenhouse range.

If carnations are to be sold right away, they are placed in water in vases with a preservative and held at a uniform 40°F until sold by the retailer.

Carnations may be stored at 31°F up to 4 weeks. They are stored in closed containers that do not absorb moisture but allow air transfer. The flowers are not in water during storage, but when removed, the stems are recut and placed in vases containing 80° to 90°F water. There should be a preservative in the water. They are held at an air temperature of 40°F until shipped.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Learning Resources

Supplies:

Terminal cuttings of carnations for propagation

Coarse, porous, humus soil

Commercial catalogs

References:

The Ball Red Book. Reference No. 29.

Commercial Flower Forcing, Seventh Edition. Reference No. 7.

Flower and Plant Production. Reference No. 15

Audio Visual Aids:

"Colorado Carnations" (26 min., color, sound motion picture).
Modern Talking Picture Service, 3 East 54th Street,
New York City, New York.

Suggested Learning Activities

1. Arrange for a class field trip to a greenhouse where carnations are grown.
2. During the visit identify some of the varieties of carnations for students.
3. Demonstrate pinching, disbudding, and packing procedures.
4. Arrange an interview with a greenhouse manager who is growing carnations.
5. Have the class plan, plant, and care for a carnation crop in the school greenhouse. See page 174b for a planting scheme.

Suggested Placement Experiences

1. Students should spend some time assisting in the planting of carnations in the greenhouse.
2. Students should become familiar with the technique of harvesting which includes removing flowers from the plants, grading, bunching, and packing.

Suggested Crop Rotations for School Greenhouses

Warm Greenhouses - 60-62°F Nights

Potted Plants:

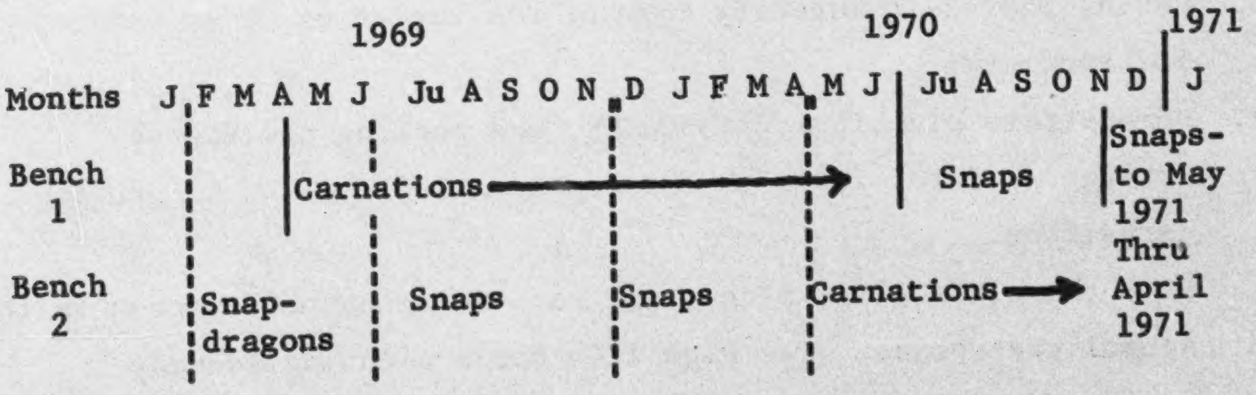
September - December	Poinsettias (Potted Chrysanthemums)
(December) January - April	Easter Lilies (Potted Chrysanthemums) (Potted Hydrangeas) (Potted Roses) (Short-term catch crops: Forcing Azaleas, Spring Bulbs)
(March) April - June	Bedding Plants (Geraniums)

Cut Flowers:

September - December	Pompon Chrysanthemums (Standard Chrysanthemums)
January - April	Chrysanthemums

Propagation - use 65-70°F bottom heat.

Cool Greenhouses - 50-52°F Nights


1969
1970
1971
Months J F M A M J Ju A S O N D J F M A M J Ju A S O N D J
Bench 1
Carnations
Snaps
Snaps- to May 1971
Bench 2
Snap- dragons
Snaps
Snaps
Carnations
Thru April 1971

Test

1. What are the varieties of carnations?
2. What is the best way of propagating this plant?
3. Why is shallow planting recommend?
4. Of what value is pinching to young plants? When is it made?
5. When is the best time to harvest carnations?
6. If marketing of carnations is delayed, at what temperature should the flowers be kept?

CUT FLOWER UNIT 3

Snapdragon
(*Antirrhinum majus*)

Learning Objectives

1. To learn why snapdragons are marketed close to the growing areas.
2. To learn how to schedule snapdragon rotations.
3. To understand the manipulation of environment to produce a high quality snapdragon crop.
4. To learn how to cut, grade, pack, and market snapdragon.

Key Questions

1. Why are snapdragons marketed close to production areas?
2. Why have snapdragon cultivars been placed in four response groups?
3. Why must snapdragon seedlings be carefully handled?
4. Why are snapdragons usually grown "single stem"?
5. How is soil moisture control used to strengthen stems in snapdragon?
6. Why is no fertilizer applied after florets begin to expand?
7. What effect does additional carbon dioxide in the greenhouse have on snapdragon?
8. At what stage should snapdragon be cut?
9. Why can snapdragon be shipped only short distances?

New Words

Floret - an individual flower in a spike
Geotropism - a growth change due to gravity
Response group - a group of cultivars that perform similarly
Spike - a stem with the flowers (florets) spaced along the upper end

The snapdragon is one of the two main spike flowers used by floral designers. The other one is the gladiolus.

Snapdragons do not ship well for two reasons. If they are enclosed in an air tight container for several hours, the ethylene-like gas they give off accumulates in sufficient quantity to cause the florets to loosen and drop (called "shattering"). The second reason is that tips of the spikes turn upward if the flower stems are placed horizontally for several hours. When the stems are again placed upright, the tip of the stem once more bends upward. These two bends cause a very objectionable crook in the stem. So, snapdragons are usually grown about 1 hour's travel time from the market (50 to 60 miles).

The snapdragon is a perennial plant native to the Mediterranean region.

Growing a high quality snapdragon crop requires careful attention to details as well as considerable skill. Snapdragons are not a profitable crop unless grown well. The most profitable snapdragon crops are those flowered from mid-December through May.

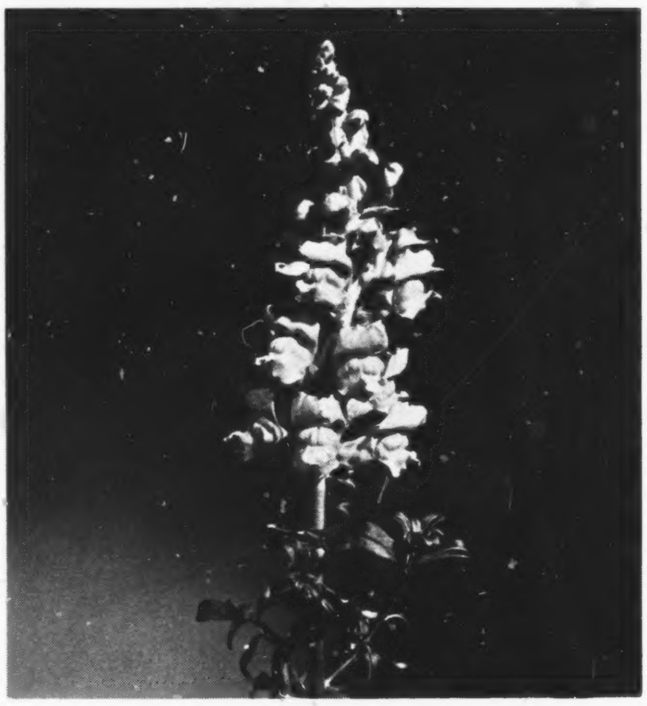


Figure 105. A snapdragon spike. (Courtesy of George J. Ball, Inc., West Chicago, Ill.)

Response Groups

Snapdragon cultivars vary considerably in their response to temperature, light intensity, and day length. Researchers have placed them into four different forcing groups. Each group is appropriate for flowering only during certain seasons of the year as shown in Table 17.

Table 17. Harvesting periods for greenhouse snapdragons. Planting and growing periods of 2-1/2 to 4 months precede (to the left on the chart) the harvesting periods. Any one planting will be harvested within a 7- to 10-day period. This scheme applies only to greenhouse production north of the 38th parallel (a line from Norfolk, Virginia, to San Francisco, California). (Adapted from Ball 1969 catalog, George J. Ball, Inc., West Chicago, Illinois.)

	MONTHS											
	J	A	S	O	N	D	J	F	M	A	M	J
RESPONSE GROUPS	Group IV		Group III		Group II		Group I		Group II		Group III	

	Sow	Flower	Weeks
Response Group I. High quality with 50°F night temperature, short days, and low light of midwinter.	Aug. 15 Aug. 31	Dec. 10 Feb. 15	16½ 23
Response Group II. Require longer days and more light than those in Group I. Long-day treatment for the first 2 months of the fall sowing will speed the crop.	Sept. 11 Dec. 10 July 24 Aug. 9	Feb. 15 May 10 Oct. 24 Dec. 10	22 21 13 17½
Response Group III. Require long days, and give best quality when flowered in early fall or late spring.	Dec. 10 March 21 June 18 July 16	May 10 June 30 Sept. 10 Oct. 25	22½ 14 12 14½
Response Group IV. Require long days and high light intensities, and are tolerant of high temperatures. They produce good quality mid-summer crops.	March 28 June 10	July 1 Sept. 1	13 11½

The response group schedules given above and on the previous page apply when planting small seedlings, growing single-stem (unpinched) crops, and using a night temperature of 50°F. It should be noticed that the time from sowing seeds to flowering varies from about 11½ weeks for a June 10 sowing of a Group IV snapdragon cultivar, to about 23 weeks for an August 31 sowing of a Group I snapdragon cultivar.

One can make estimates for flowering between the dates given in the tables. For example, if a snapdragon crop is desired half way between December 10 and February 15 (or January 12), the seed should be sown on a date half way between the two given in the table (or August 23).

In spite of careful planning to cut snapdragons for a certain week, unusually bright weather or unusually dull weather can speed or delay the crop by as much as several weeks.

Breeding improved snapdragon cultivars for greenhouse culture is being conducted continuously. It would be a good idea to consult current wholesale seed catalogs for the most up to date list of these cultivars.

Propagation

Snapdragons are propagated by seeds. The seeds are packed with 2,000 seeds per packet. A grower may expect to get 800 good seedlings from each packet of seed. The seeds are sown on the surface of a finely screened medium. The medium should be a light mixture with peat and sand, but the fertilizer content must be low. If this medium is light, moisture will get to the small seeds sown on the surface. When the true leaves are expanded, an application of a starter solution, as for bedding plant seedlings is made as explained on page 125.

Damping-off is prevented by using steam sterilized soil. Irrigating from the bottom of the container also helps control this disease. The use of fans, as explained on page 121, is also helpful.

Bench Preparation and Planting

A porous, well drained soil is essential for snapdragons. It must also be steamed, and must be low in soluble salts.

If snapdragons are propagated at 65° to 70°F, the seedlings should be ready for transplanting about 3 to 4 weeks after sowing. You may wish to read more details about starting snapdragons from seed on pages 366 and 367 in Reference No. 29, The Ball Red Book. Seedlings will develop more rapidly and uniformly if they are given long days as described on page 35 until they have reached the transplanting stage.

Snapdragons should be transplanted to the growing benches when they are about 1 inch high and the first set of true leaves have appeared. If transplanting is delayed until later than this stage, a poor quality, uneven crop will be produced. During the transplanting process, snapdragon seedlings must be handled only by their leaves. The stems are very easily bruised and transplant losses will be very high if they are handled by the stems.

Single-stem crops are spaced 4 by 4 inches for summer flowering, and 4 by 6 inches for winter flowering crops. Snapdragons are usually grown as single stem crops for the following reasons:

a. The planting-to-harvest time is shorter.
b. Rotations are "tighter" (more crops per year).
c. The harvesting time is shorter.
d. The flowers are of more uniform quality.

Pinched crops require fewer seedlings because they are grown at a spacing of 8 by 8 inches. The harvesting time for a pinched crop is spread over a longer period, which may be an advantage to a retailer-grower, who needs a steady supply. Only certain cultivars respond well to pinching, others may produce few shoots, or the shoots may be very unequal in size. Pinching is done when the plants have grown to a height of about 8 inches, and have lateral shoots about 1 inch long. The top is removed to leave 3 sets of strong leaves with axillary shoots. These plants are opposite-leaved, so this results in 6 shoots. A week or two later, the number of shoots is thinned (pruned) to 4 per plant.

Temperature Control

Cultivars grown in winter, late fall, and early spring, should be grown at a night temperature of 50°F. In a prolonged period of dull weather, many growers reduce this to 48°F. The day temperature is allowed to rise to 55°F on cloudy days and 60°F on sunny days.

Cultivars grown in spring, summer, and early fall are grown at 60°F night temperature, with daytime rises up to 65° or 70°F.

Whenever possible, seedlings and young plants should be grown at 60°F night temperature, regardless of response group, and regardless of the time of year. More rapid growth and better quality are obtained if this temperature is used, rather than 50°F at night.

Watering

Each transplanted seedling should be watered individually within 15 minutes after transplanting. Once growth is under way, when watering is needed, the whole bench or bed may be watered at once. Slight wilting before watering is desirable for the prevention of soft stems. This is particularly important during the dull weather of winter months. Once the florets begin to expand, the plants must not be allowed to wilt between watering, or small florets will result.

Fertilizing

Fertilizer applied in the irrigation water as for other crops is appropriate for snapdragons. For this purpose a 20-20-20 analysis fertilizer is usually used at the 100 to 200 ppm N rate. When buds become visible, however, no more fertilizer should be applied, or soft florets, with very short keeping life, and weak stems will result.

Snapdragons are especially sensitive to injury from high soluble salts in the soil. This can be troublesome if the soil was previously used for growing a greenhouse crop.

Carbon Dioxide

Adding carbon dioxide to the greenhouse air to give levels of 700 to 1000 ppm (see Page 28) gives more uniform cropping, with improved quality. It may also speed the crop by 7 to 14 days. This increase in carbon dioxide level should be accompanied by an increase in night temperature to 52°F for best results. This increase in carbon dioxide can be done only during daylight hours when the appropriate temperatures can be maintained without opening the ventilators, or otherwise bringing about an air change.

Pest Control

Aphids are the most common pests of snapdragons. They cause twisted or misshapen leaves at the tip of the plant.

Some of the other pests that are troublesome include: thrips, two-spotted mite, white fly, cyclamen mite, symphylan, and cabbage looper.

Growers should always be on the look out for any of these pests and use the most recent recommended control practices. See control measures on pages 58 to 63.

Quality Control

Growers need to sell good quality flowers in order to demand a high return on their investment. Many factors already mentioned may affect quality. Some of the troubles that may occur with a crop are:

Chlorosis - a loss of green color in the leaves due to poor drainage and/or too much fertilizer

Floret drop or "shatter" - is caused primarily by pollination by bees and other insects (spring, summer, and fall crops must be grown in greenhouses with screened ventilators) and the effect of gases such as ethylene

Floret skip - a condition in which some florets of a spike fail to develop. This is a problem that arises only if the snapdragons are subjected to unusually cool temperatures during the formation of the spike

Hollow stems - may occur in the winter if the nitrogen level has been too high

Wilt - is usually caused by physical situations such as poor temperature control in the winter months, but may be caused by a particular pathogen

Harvesting

The lower florets of the snapdragon spike expand first, and the florets of the tip expand last. Flowers should be cut when from 6 to 15 of the florets are fully open. Most growers cut the stem just above the soil.

Grading, Bunching, and Packing

Immediately after cutting, the foliage is stripped from the lower 6 inches of the stem. Within 15 minutes the stems are placed in water, in a 40°F refrigerator.

Snapdragons are graded according to spike length and stem length and are bunched in dozens.

Snapdragon spikes should never be laid on newspapers, because the light-colored cultivars pick up newsprint ink, disfiguring the florets.

Grades suggested by the Society of American Florists are given below.

Table 18. Society of American Florists Standard Snapdragon Grades

Grade Designation	Minimum Number of Open Flowers	Minimun Stem Length in Inches
Blue	15	36
Red	12	30
Green	9	24
Yellow	6	18

When snapdragons are shipped, they are packed in upright hamper-type containers. The reason for this is because snapdragons tend to bend upward at the tip if they remain in a horizontal position for 2 hours or more. (This is called a geotropic response. You may want to read further about it in a text on plant physiology). This response is illustrated in the following page.

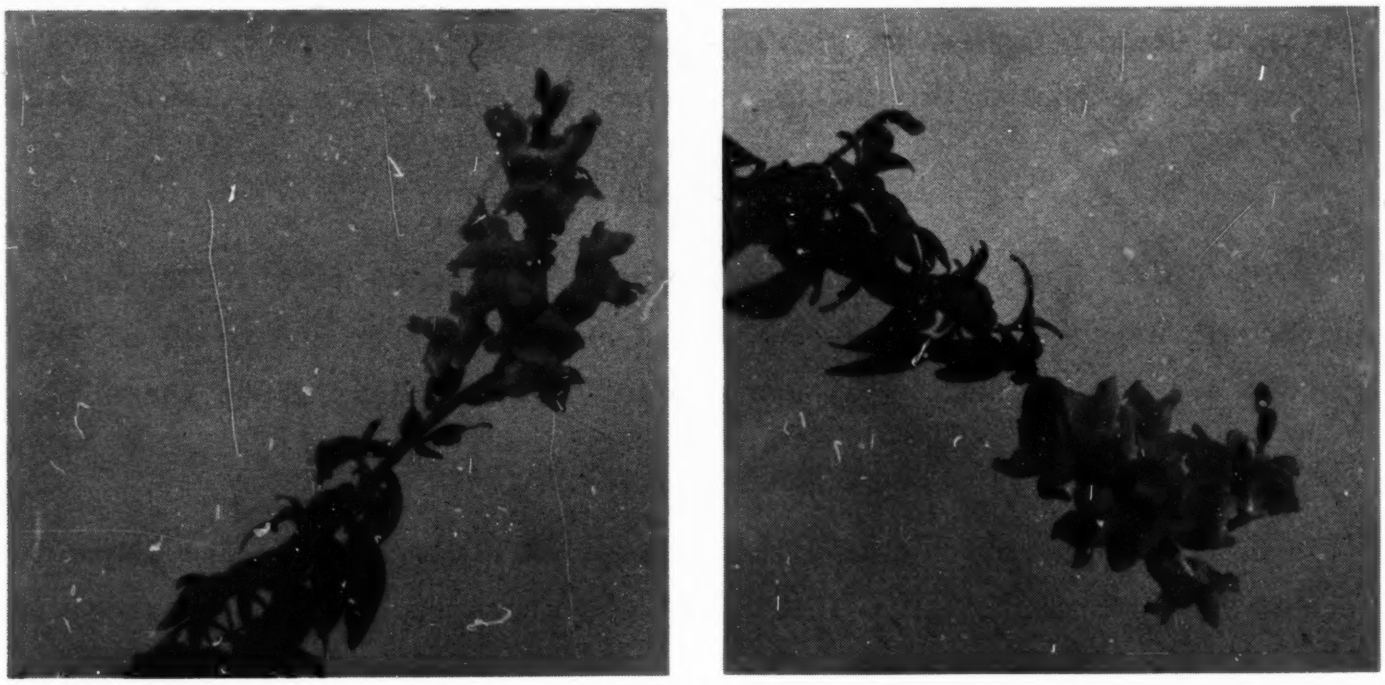


Figure 106. The stem tip of a snapdragon spike becomes vertical in about 2 hours, regardless of the position in which the stem has been placed. Gladiolus stem tips respond similarly.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

References:

Commerical Flower Forcing, Seventh Edition. Reference No. 7

Flower and Plant Production. Reference No. 15

1969 (or current) Cornell Recommendations for Commercial Floriculture Crops. Reference No. 10

The Ball Red Book, Eleventh Edition, 1965. Reference No. 29

Snapdragons, A Manual of Culture, Insects and Diseases and Economics. Reference No. 23

Supplies:

Wholesale seed catalogs

Snapdragon seeds

Suggested Learning Activities

1. If a local greenhouse grows snapdragons, have the class visit the greenhouse and ask the greenhouse manager to explain how he produces the crop.
2. Using the charts and response groups in the text as well as wholesale catalogs, have the class work out a one-year rotation for year-around snapdragon production. Include cultivars and dates for sowing, transplanting, and harvesting.
3. Have the class sow the seeds and grow at least one snapdragon crop in the school greenhouse using the plans they worked out for Problem 2.
4. Have the class cut and grade part of a snapdragon crop in the school greenhouse, or if possible in a nearby commercial range.
5. Have the class work out demonstrations of "geotropism" and "shattering" with cut snapdragons.

Test

1. What characteristics do snapdragons and gladiolus have in common?
2. Why is a snapdragon cultivar from Response Group IV unsatisfactory for January flowering?
3. Why are snapdragon seedlings planted in the bench when still very small?
4. Why are snapdragons usually grown "single stem"?
5. What will happen to a snapdragon crop if it is fertilized after color shows in the florets?
6. Why must good judgement be exercised in determining when to water a midwinter snapdragon crop?
7. Why are snapdragon flower stems usually shipped in an upright position?

CUT FLOWER UNIT 4

Additional Crops

Learning Objective

To develop a basic understanding of the cultural requirements for roses and orchids.

Key Questions

1. What are the peak sales periods for rose? for orchid?
2. How is the rose propagated?
3. How is the orchid propagated?
4. What is the harvesting procedure for rose? for orchid?

New Words

Agar - a special medium derived from seaweed

Sepals - small leaves surrounding the flower where it is attached to the stem

ROSES

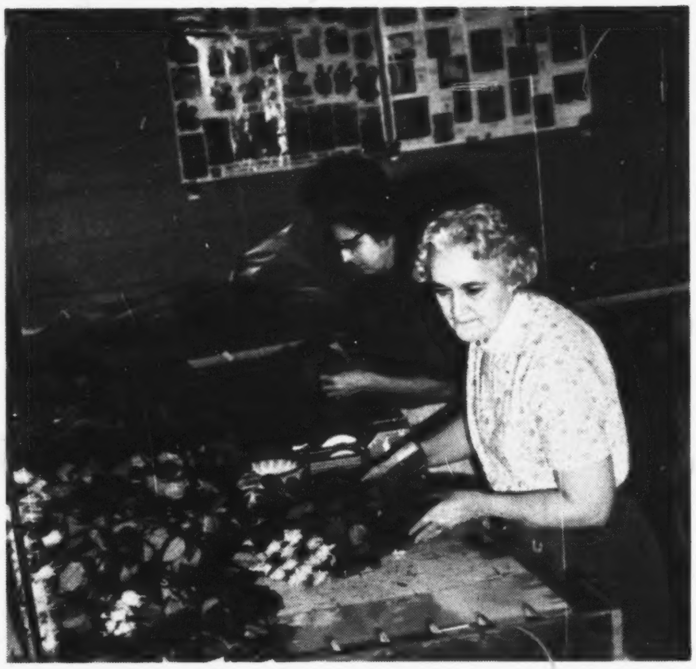


Figure 107. Grading roses.

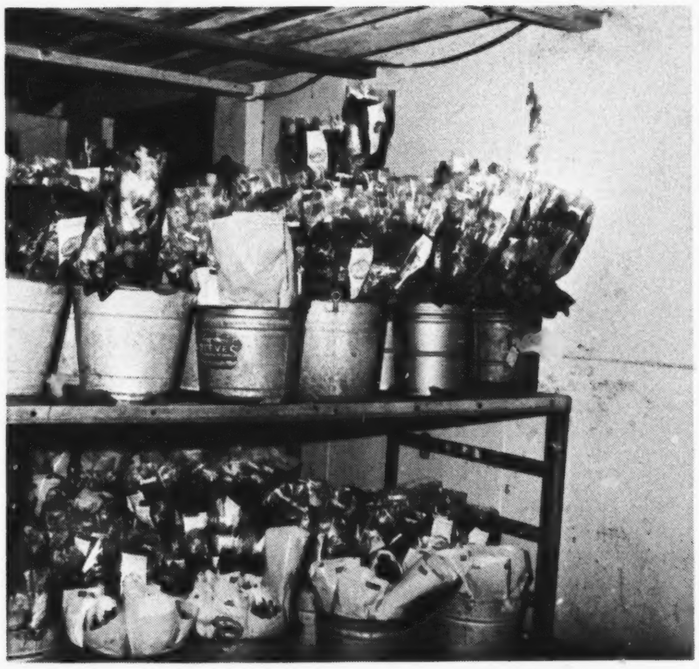


Figure 108. Roses in spiral wraps in water in a refrigerator after grading.

Sales Period - peaks at Christmas, Valentine's Day, Easter, and Mother's Day, but sold throughout year

Propagation - dormant Hybrid Tea and/or Sweetheart plants ordered one year in advance of planting in late spring at 12 x 12 inch spacing, replanted every 4 years

Soil - same as for chrysanthemums

Fertilizing - same as for chrysanthemums

Light - intensity as high as possible with temperature control

Temperature - 58°F to 62°F night, depending upon cultivar; washed air cooling essential in summer

Carbon Dioxide - 1500 ppm gives high production and good quality

Timing - pinching pea-size buds 8 weeks before Christmas, 8 weeks before Valentine's Day, 7 or 6 weeks before Easter, 5 weeks before Mother's Day

Pests - two-spotted mites, aphid, thrips, mildew, nematodes

Harvesting - cut in morning and in afternoon; when sepals curl or first petal opens; in fall and winter leave stub with two 5-leaflet leaves, in spring and summer cut to a "hook"; refrigerate quickly in water with flower preservative; may be held dry at 31°F as for carnations

Grading - according to 3-inch stem length increments; 13 or 25 roses are spirally wrapped in a sheet of paper to make a bunch

References - Commercial Flower Forcing, Ref. No. 7., and Roses Manual -1970, Ref. No. 27.

Audio-Visual Aid -"What's Behind a Rose" (18 min., sound, color, motion picture) Roses, Inc., Office of Public Relations Director, 60 East 42nd Street, New York City, New York

ORCHIDS

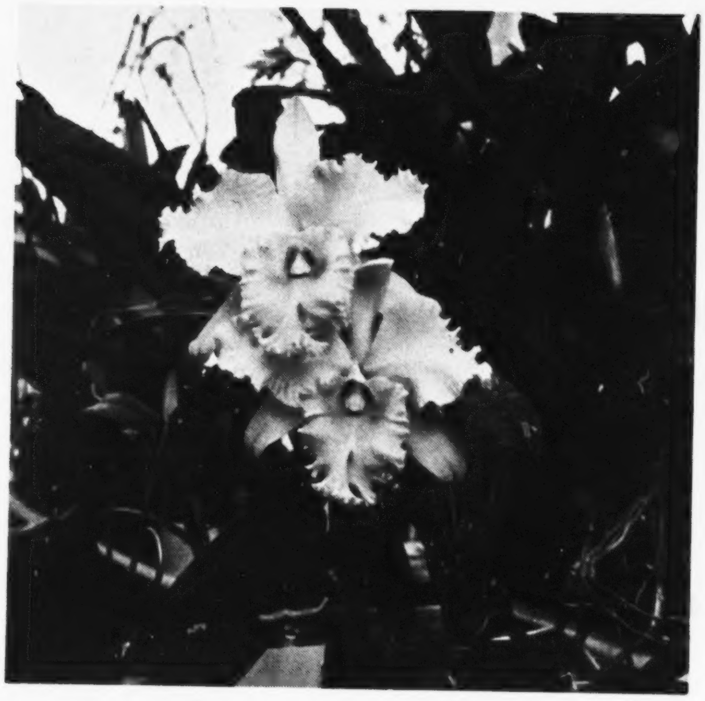


Figure 109. Cattleya Orchid (Cattleya hybrid)

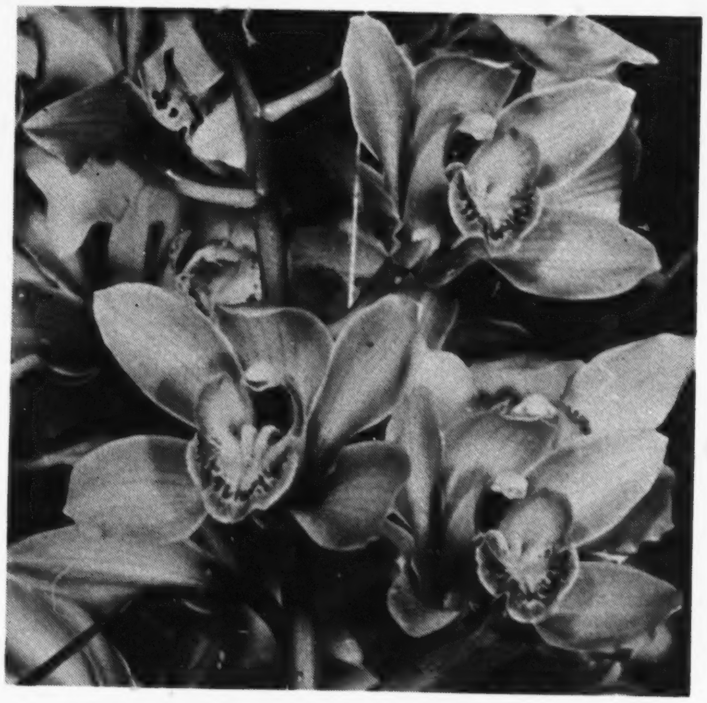


Figure 110. Cymbidium Orchid (Cymbidium hybrid)

Sales Period - Christmas, Valentine's Day, Easter, Mother's Day, some throughout the year; cymbidiums, December through May

Propagation - seed sown on sterile nutrient agar by specialists

Containers - 6-inch standard clay pot

Mediums - cattleyas, fir bark and osmunda fiber; cymbidiums, fir bark and redwood fiber

Light Intensity - cattleyas, under 2000 fc., shade April 1 to October 15; cymbidiums, full sunlight, light shade in flower

Photoperiod - certain cattleya cultivars respond

Temperature - cattleyas, 55^{o} to 65^{o}F nights, depending upon cultivar and stage of flower buds; cymbidiums initiate and develop flower buds only below 65^{o}F

Carbon Dioxide - 1500 ppm for cymbidiums increases number of blooms

Nutrition - 18-18-18 in irrigation water at a 100 ppm N rate

Relative Humidity - 60 to 80% RH

Pests - orchid weevil, slugs, snails, scales, leaf spots, virus

Harvesting - flowers must "harden" on the plants for 3 days after opening, cut and placed individually in water tubes, refrigerated at 50^{o}F, shipped tied into bottom of boxes to prevent movement

Cultivars - hundreds are grown

Reference - Commercial Flower Forcing, Seventh Edition. Reference No. 7.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

There are many additional crops grown for sale by producers. Refer to the references cited for information on these popular plants.

Learning Resources

References:

Commercial Flower Forcing, Seventh Edition. Reference No. 7

Roses Manual - 1970. Reference No. 27

Audio-Visual Aid:

"What's Behind a Rose"

Suggested Learning Activity

Conduct a class trip to greenhouses that grow cut flower roses and orchids.

Test

1. Name three peak sales periods for roses.
2. Name three peak sales periods for orchids.
3. How often are rose bushes replanted?
4. Where should roses be cut in fall and winter? in spring and summer?
5. Describe the propagation of orchids.

PROBLEM AREA 6

VEGETABLE PRODUCTION

Tomatoes and lettuce are two important vegetable crops grown in greenhouses in Northeastern United States. The present wholesale value of greenhouse tomatoes is probably about 18 million dollars annually while for lettuce it is about 3 million dollars.

VEGETABLE PRODUCTION UNIT 1

Tomato
(*Lycopersicon esculentum*)

Learning Objectives

1. To learn the importance of greenhouse-grown tomatoes as a commercial crop.
2. To learn how to plan greenhouse-grown tomato rotations.
3. To learn the cultural techniques of producing high quality greenhouse tomatoes.
4. To learn how to harvest greenhouse tomatoes.

Key Questions

1. What is the annual wholesale value of greenhouse-grown tomatoes in the United States?
2. How many crops of tomatoes are usually grown in a greenhouse in one year?
3. At what growth stage are greenhouse tomatoes planted in the greenhouse?
4. How are greenhouse tomato flowers pollinated?
5. At what stage are tomatoes picked for shipping to distant markets?

New Words

Interveinal - refers to the spaces between veins in a leaf
Flat - a tray or box approximately 15 inches by 20 inches by 2-3/4 inches filled with soil and used for sowing seed
Transplant - removing a young plant from a flat and placing it in a pot or other container
Topping - removing the tip of a plant to prevent it from becoming taller

The relative importance of greenhouse tomatoes in the northeastern states may be seen in Table 19. The estimates are from figures available from the U. S. Census Bureau.

Table 19. Estimated wholesale value of greenhouse-grown tomatoes in certain northeastern states.

State	Estimated Wholesale Value
Ohio	$13,000,000
Indiana	1,100,000
Massachusetts	600,000
Michigan	550,000
Illinois	500,000
New York	450,000
Kentucky	350,000
Wisconsin	350,000
Pennsylvania	150,000

Cultivars

Selection of a cultivar is a very important step in tomato production. Varieties are selected with the following things in mind: (1) high yields, (2) uniform bright red color, (3) smooth surface, (4) small seed cells, (5) firm flesh. The variety should also be a strong vigorous grower with a good root system. Some of the more popular varieties are Michigan-Ohio Hybrid, Ohio W-R 7, Pink Globe, Waltham Hybrid, Spartan Red 8, and Spartan Pink 10. Some varieties recommended especially for plastic greenhouses are Tuckcross, Tuckgreen, Vinegreen, Manalucie, and Manapel.

Schedules

Table 20. Greenhouse tomato planting schedules.

Activity	Single Tomato Crop	Fall Tomato Crop Followed by Spring Tomato Crop		Spring Tomatoes Following Fall and Winter Lettuce
		Fall Crop	Spring Crop	
Plant seed	Sept. 10-Oct. 10	June 25-July 1	Nov. 1-10	Dec. 20-Jan. 20
Plant	Nov. or Dec.	August 10	Jan. 10-15	Feb. 25-Mar. 20
Begin Harvest	Feb. or March	Oct. 1	April 1-10	May 10-20
Peak Production	May and June	Oct. and Nov.	May 15-June 15	June 20-July 10
Remove Crop	Late July or August	Dec. 15-Jan. 1	July 15-25	July 25-Aug. 15
Sterilize Soil	August		July 15-Aug. 1	Aug. 1-Sept. 15

Tomato fruit is not produced in northern greenhouses during January and February because the sunlight intensity is too low for production that is economically competative with outdoor-grown southern tomatoes shipped to northern markets during the period.

Soil

Soil used for growing greenhouse tomatoes must be well drained. A sandy clay loam is preferred. The soil should be steamed between every crop. Steaming at 180°F for 30 minutes is sufficient. Greenhouse vegetables are grown directly in the floor of the greenhouse. For good drainage, tile lines are laid about 20 inches apart and 12 to 16 inches deep throughout the greenhouses. These tile lines are usually arranged in sections so that steam can be injected into them for steaming the soil in one section of the greenhouse at a time. The soil should be tested for nutrient level just before planting and retested every 30 to 60 days.

Propagation

Tomato seeds are sown in steamed flats of soil, vermiculite, or in mixtures of soil and vermiculite. The seeds should be sown in rows about 1-1/2 inches apart and about 1/4 inch apart in the row. The seeds are then covered with finely screened soil or vermiculite and gently but thoroughly watered. Each flat should be labeled showing the cultivar and date of sowing.

The flats may then be placed under a mist propagation system, or may be wrapped with polyethylene film. The temperature of the medium should be 65° to 70°F. As soon as there is any evidence of seed germination, which takes about three to four days, the flats should be removed from the mist, or the polyethylene cover removed. They should be placed in full sun in a 60° to 65°F greenhouse. They should immediately be fertilized with a "starter solution" (see page 125) that is high in phosphorus. A gentle air current should be provided for them at all times. After the cotyledons (seed leaves) unfold, the flats should be placed, in a 50° to 55°F greenhouse for 10 days in sunny weather, 21 days in dull weather, which results in earlier and heavier yields. If you wish to read more about this, see Reference No. 25 Practices for Increasing the Fruit Crop of Greenhouse Tomatoes. Two or three days before transplanting, they should receive another application of starter solution.

Transplanting

At the stage when the "true" leaves appear, tomato seedlings are transplanted into 4-inch standard clay pots, 4" bands, 4" composition squares, or pressed peat pots of equivalent volume. A steamed soil mixture of 2 or 3 parts loam soil, 1 peat, and 1 inert ingredient is usually used. Growth is then continued at 60° to 65°F nights.

Tomato plants are grown in these containers for about four to six weeks. During this time they should be fertilized at 7 to 10-day intervals with a 10-52-17, or similar analysis soluble fertilizer at 1 oz. per 2 gallons water.

Planting

Tomato plants should be planted in the floor of the greenhouse when the first flower buds appear. This is from 6 to 9 weeks after seed sowing, depending upon the time of year (see Table 20, page 193).

An ideal plant is a "square" plant -- one that is as wide as it is tall. See Figure 111.

The soil in the floor of the greenhouse is prepared for planting by applying 100 tons of well-rotted cow manure per acre and 1500 lbs. of a 0-20-20 analysis fertilizer per acre. These materials are incorporated into the soil. The soil is then steamed.

The plants are usually spaced 18 inches apart in rows 27 inches apart.

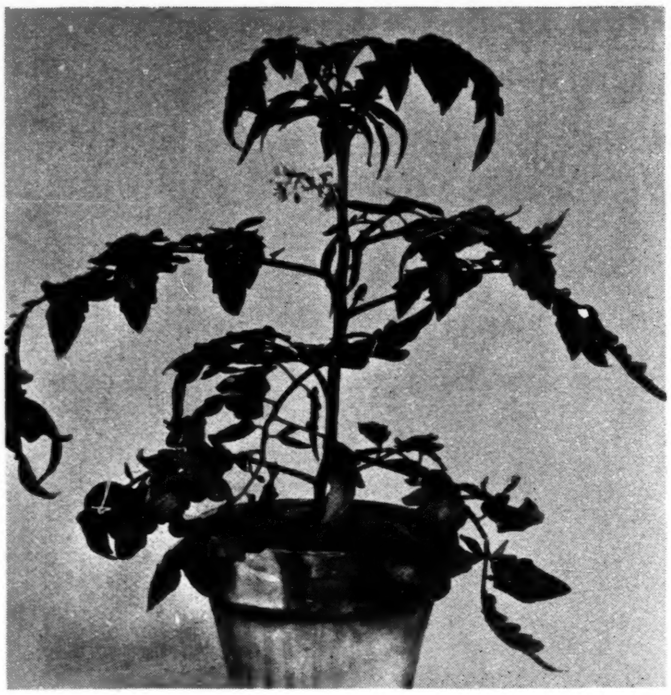


Figure 111. A potted tomato at the right stage to be planted in the floor of the greenhouse. This plant was "cooled" in the seedling stage. (Courtesy, Agricultural Experiment Station, Michigan State University, East Lansing, Michigan.)

Each plant is supported by a four-ply string stretched from the base of the plant to a 12-to 14-gauge wire running 7 to 8 feet directly above the row of plants. The string is tied to the base of the plant with a slip knot. It is tied to the wire with a loop knot that is easily loosened. About 2 feet of excess string is allowed to hang from the wire. Once a week the upper end of the string is loosened slightly and wound around the upper part of the plant and tightened again. If the string is not loosened at the wire each time, it may become so taut that it pulls the plant from the soil.

Greenhouse tomatoes are grown as single-stem plants. Excess lateral shoots are removed by going over the plants once a week and snapping them out sideways with pressure from the fingers. When the plant has reached the wire, the tip is removed to prevent further growth.

Fertilizing

At the time of planting, the plants should be fertilized with a soluble 10-52-17 (or similar) analysis fertilizer at 1 oz. per gallon of water. About 1 cupful of this solution is applied to the soil at each plant.

From the time of planting until 10 to 15 fruits are set, apply 150 lbs. of a 10-52-17 fertilizer per acre every 10 to 14 days, or whenever the plants are watered. This could be applied in the irrigation water at 3-1/2 lbs. per 100 gallons of water.

After 10 to 15 fruits are set, and until the stage when 4 to 5 clusters are set, apply 150 lbs. of a 10-50-30 analysis fertilizer every 7 to 10 days until the pink color begins to appear in the first fruit.

After the fruit begins to ripen, apply a 13-0-44 analysis fertilizer (potassium nitrate) at the rate of 150 lbs. per acre at the time heavy irrigations are made.

If interveinal yellowing of the lower leaves appears, apply magnesium sulfate at about 350 lbs. per acre.

After the plants are "topped," (the stem tip removed), no more fertilizer is applied. Greenhouse tomatoes are usually topped at about 6 feet high. This usually results in 5 clusters of fruit per plant.

At topping time a straw mulch is applied to the walk spaces between the rows of plants. This straw tends to remove the nitrogen from the soil, resulting in firmer flesh in the fruit.

The soil in which tomatoes are growing should be sampled and tested at monthly intervals. The following levels are desirable: pH- 6.5 to 7.2, N- 1 to 3 ppm., P- 20 to 50 ppm., K- 40 to 120 ppm., Ca- 100 to 240 ppm., Mg- 5 to 10 ppm. A "K" value of 80 is not harmful.

Watering

Watering is usually done through perforated hoses laid on top of the shallow trenches in which the tomato plants have been planted. Most growers use soluble fertilizer solutions injected into the irrigation water.

In growing greenhouse tomatoes, the producer attempts to obtain plants that will give high yields of good quality. These objectives can be met by developing plants with heavy stems and dark green leaves. Along with proper fertilization practices, and careful attention to temperature control, controlled watering will develop this kind of plant. During dull weather in midwinter, the plants are allowed to dry to the point of showing slight wilting. They are then thoroughly watered, and not watered again until they again show moderate wilting. In early fall, spring, and summer, tomatoes should be watered before the wilting stage. One or two waterings per week are normally required. In midwinter the watering intervals may extend to 2 or even 3 weeks.

Temperature Control

Tomatoes, except for the early stages indicated under propagation, are carried at 58° to 65°F. The lower temperature is used in dull, midwinter weather. Temperature has important effects on tomato plants. Temperature can affect number, shape, size, color, and yield of tomatoes. Because of poor heating and ventilation, plastic greenhouses have serious limitations for tomato production.

Carbon dioxide

Carbon dioxide enrichment of the greenhouse atmosphere to about 1500 ppm of CO_2, in the same manner as for flowering greenhouse crops, has been found to nearly double the yields of some cultivars of greenhouse tomatoes. The use of supplemental CO_2 is usually a standard practice in greenhouse tomato culture.

Pollination

In order for fruit to be produced, tomato flowers must be pollinated. This usually occurs outdoors because of the wind movement of the plants, but in greenhouses, pollination may not take place naturally. There are two solutions to this problem. One is that a metal or wooden rod may be struck against the supporting wires for the plants, shaking loose the pollen, causing pollination. A second method is to spray the flower clusters with a mixture of organic acids (sold as "Blossom-Set"). This spraying will cause fruits to enlarge and ripen without seeds. Sometimes seedless tomato fruits develop undesirable hollow spaces. Striking of the wires is usually done every day; spraying, once a week.

No Smoking!

Tobacco smoke and particles are very likely to carry virus diseases, (tobacco mosaic virus, cucumber mosaic virus), that can cause drastically reduced growth, yields, and fruit quality in greenhouse tomatoes. Workers and visitors are not permitted to smoke or carry tobacco into greenhouses in which tomatoes are growing. People who smoke during nonworking hours are required to thoroughly wash their hands in hot, soapy water before entering the greenhouse.

Plant Disorders

Plant disorders may be due to improper fertilizer practices, infestations of pests, or disease infections. The following table may be helpful in diagnosis and treatment of some disorders of tomatoes.

If you wish to read about control of pests and diseases in greater detail, see Reference No. 9. Control of Insect Pests of Greenhouse Vegetables, Reference No. 26. 1969 Recommended Insecticides and Miticides, and Reference 1969 Fungicides and Nematicides, and pages 148-151 of Vegetable and Fruit Growing, Reference No. 35.

Table 21. Plant disorders of greenhouse tomato.

CULTURAL PROBLEMS	REMEDY
Excessive vegetative growth	Lower fertility level, decrease water
Blossom end rot	Increase calcium level
Splitting fruit	Shade glass, lower temperature Mulch in spring with straw or peanut hulls to lower soil temperature
Yellowing between veins	Increase magnesium level
Internal browning of fruit	Eliminate virus infection
Blotchy ripening	Increase sunlight, decrease water, lower nitrogen, increase potassium, lower temperature
Purple lower leaves, especially seedlings	Increase phosphorus level

PEST OR DISEASE	CONTROL
Aphids, two-spotted mites, white flies, tomato fruit worm, army worm, pin worm	Thiodan
Tomato fruit worm, army worm, pin worm	DDT
All insects	Calcium cyanide
Aphids	Nicotine sulfate
Botrytis, Leaf Mold	Increase air circulation
Mildew	Maneb, Zineb
Botrytis stem rot	Paste of Captan and Terrachlor
Virus diseases	Prevention only

The U. S. Government has regulations concerning how soon a tomato may be marketed after applying some of the above insecticides. They are as follows:

MATERIAL	TIME
Parathion	10 days
TEPP	3 days
Malathion	15 hours
Nicotine sulfate	3 days
DDT	5 days

Production in Plastic Greenhouses

Tomatoes are often grown in greenhouses covered with plastic film rather than glass. Because these greenhouses have much lower air exchange, special problems in controlling relative humidity must be solved in order to prevent severe disease infections. You may wish to read further on this in Tomato Production in Plastic Greenhouses, Reference No. 33.

Harvesting and Marketing

The stage of maturity at which tomatoes are harvested depends on where they are to be sold. Tomatoes sold locally are harvested when nearly fully colored. Tomatoes sold at more distant markets are harvested when they are at the mature-green stage. Size is not related to maturity. Tomatoes that are at the mature-green stage exhibit cream-colored streaks at the blossom end; the brown corky ring surrounding the stem scar becomes more noticeable; the skin is tougher; and the fruit can be squeezed more easily with the hand. A good way to test for the mature green stage is to cut a sample tomato crosswise. If the pulp surrounding the seeds has become jellylike and the seeds slip aside and cannot be cut by a sharp knife in slicing, the tomato fruits are mature enough to ship.

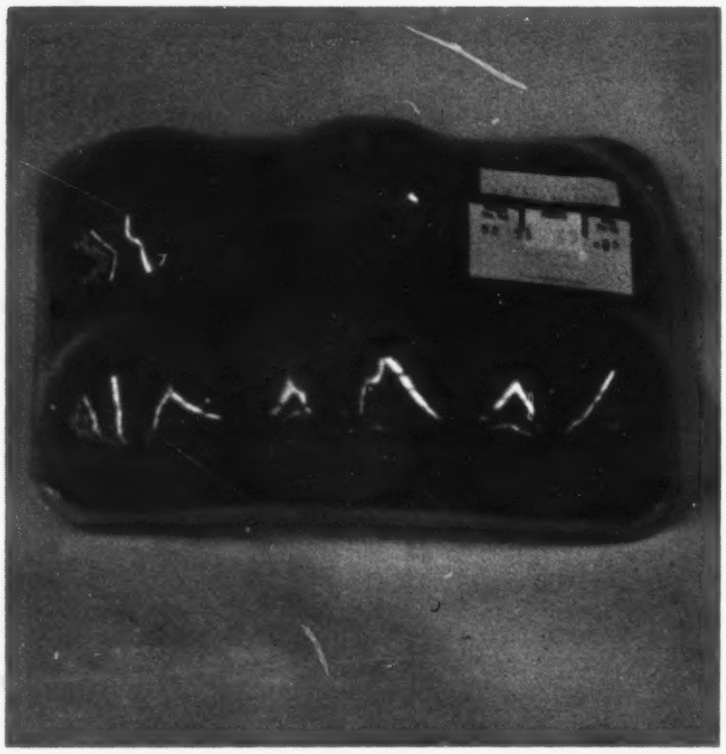


Figure 112. A package of greenhouse-grown tomatoes.

Tomatoes are generally marketed through cooperatives. This method is more convenient for the grower and has proven successful in the past. The grower should be concerned that his fruit is marketed at the desirable color. Consumers prefer red tomatoes to pink ones. Tomatoes showing at least 80% color when displayed in stores are preferred.

A yield of 15 pounds of fruit per plant may be expected with good cultural practices. Somewhat higher yields may be anticipated with the use of supplemental carbon dioxide.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

Learning Resources

Supplies

Seeds of greenhouse tomato cultivars

4-ply twine

References

Commercial Production of Tomatoes. Reference No. 8.

Practices for Increasing the Yields of Greenhouse Tomatoes. Reference No. 25.

Control of Insect Pests of Greenhouse Vegetables. Reference No. 9.

Tomato Production in Plastic Greenhouses. Reference No. 33.

Vegetable and Fruit Growing. Reference No. 35.

Audio-Visual Aids

None

Suggested Learning Activities

1. Have the students visit a greenhouse range in which tomatoes are being grown, and discuss with the manager the planting, cultural techniques, and harvesting of the crops.
2. Have students plan a tomato rotation for part of the school greenhouse.
3. Have students grow a tomato crop in the school greenhouse, using the rotation plan they have devised.

Test

1. Name the 5 leading states in greenhouse tomato production.
2. List at least three important qualities a good greenhouse tomato cultivar must have.
3. Why are midwinter greenhouse tomato crops avoided?
4. When seedling tomatoes reach the "cotyledon unfolding" stage, why are they placed at 50° to $55^{\circ}F$ for 10 to 21 days?
5. At what stage of growth are tomatoes planted in the greenhouse?

6. What is meant by a "square" tomato plant?
7. How are tomato plants supported?
8. What is meant by "topping"?
9. Why are tomato plants allowed to wilt slightly before being watered during midwinter?
10. How are greenhouse tomatoes pollinated?
11. Why is smoking not permitted in tomato-producing greenhouses?
12. At what stage of maturity are tomatoes harvested for shipment to distant markets?
13. How many pounds of fruit should a greenhouse tomato plant yield?

VEGETABLE PRODUCTION UNIT 2

Lettuce
(*Lactuca sativa*)

Learning Objectives

1. To learn how to produce a crop of greenhouse lettuce.
2. To learn the different varieties of lettuce.
3. To learn to identify and control some of the pests and diseases of greenhouse lettuce.

Key Questions

1. What are the two major groups of lettuce cultivars?
2. What are the ideal weather and soil requirements for greenhouse lettuce?
3. Why is transplanting necessary?
4. How is harvesting and packing done?
5. After harvesting, at what temperature should head lettuce be stored?

New Words

"Bolting" - production of a seedstalk in lettuce or cabbage
Crisp leaves - leaves that are so stiff they are easily broken
Pliable leaves - slightly soft leaves that are not easily broken
Seedstalks - the stem of a plant on which seeds are developed

Lettuce is one of the most important vegetables and is the most popular salad vegetable. It is native to Asia and was known and cultivated several hundred years B.C.

The 12 leading states in greenhouse lettuce production are listed below, together with an estimate of the annual wholesale value for each state.

Table 22. Twelve top states in greenhouse lettuce production.

State	Annual Wholesale Value	State	Annual Wholesale Value
Ohio	$1,100,000	New York	$ 40,000
Indiana	650,000	Wisconsin	35,000
Michigan	300,000	Kansas	30,000
Missouri	110,000	Illinois	20,000
Massachusetts	95,000	Pennsylvania	18,000
Kentucky	90,000	New Jersey	9,000

Cultivars

Only two lettuce cultivars are grown extensively in greenhouses. One is "Grand Rapids, Tip-Burn Resistant," a leaf lettuce developed especially for greenhouse production. The other cultivar is a small, head-type called "Bibb."

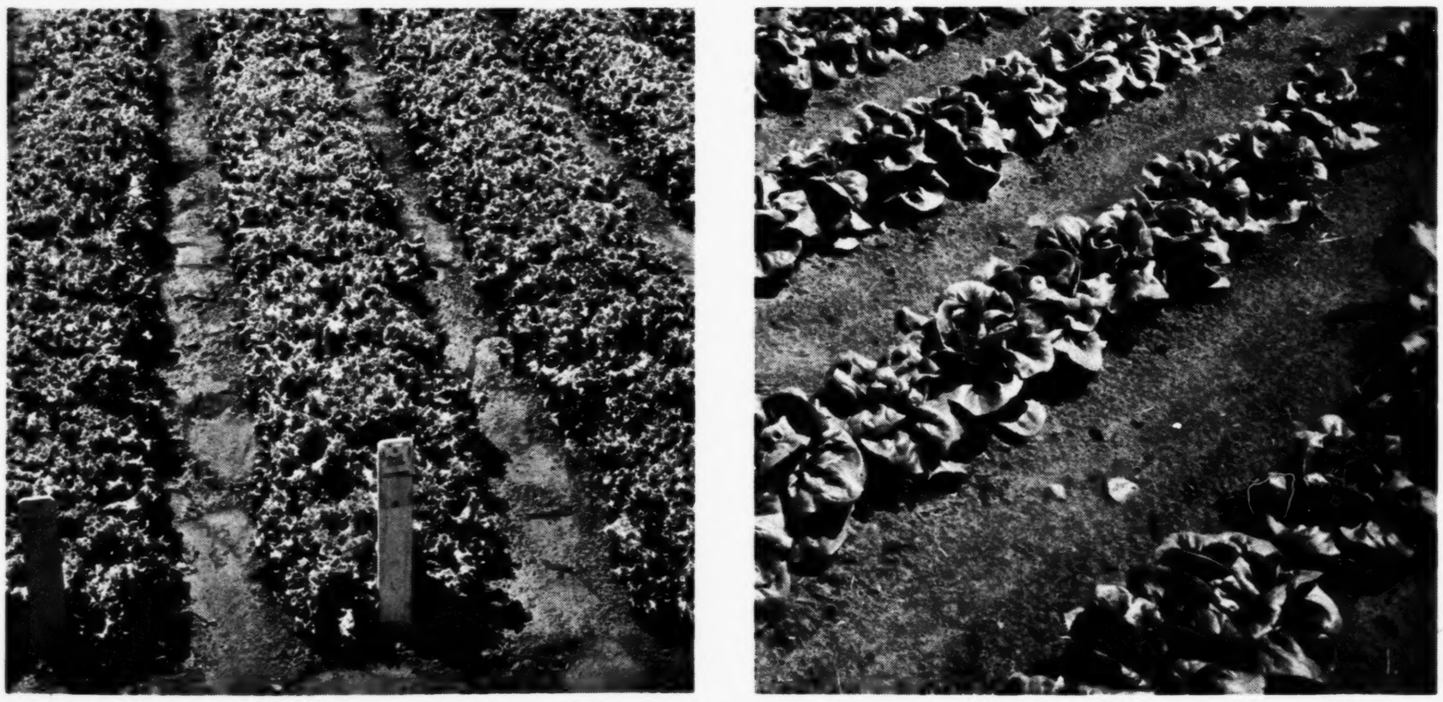


Figure 113. Greenhouse lettuce cultivars; left, "Grand Rapids, Tip-Burn Resistant," right, "Bibb." (Courtesy, Joseph Harris Co., Inc., Rochester, N.Y.)

Rotations

Greenhouse lettuce requires 6 to 12 weeks from the time of planting in beds until the time of harvest. The time varies with the season and the size demands of the market. When lettuce is scarce on the market, an early harvest of small size bunches or heads may be readily sold at a profit.

A typical rotation with three lettuce crops appears as follows:

Table 23. A Crop Rotation Plan for Greenhouse Lettuce.

Seed Sown	Planted in Beds	Crop Harvested
August 1	September 1	November 15
October 22	November 22	February 10
January 17	February 17	April 15

Usually, the greenhouse manager works out schedules that may call for sowing, planting, and harvesting crops each week. This gives continuous production, and a more constant work load. Lettuce is sometimes grown as a fall and winter crop, to be followed by greenhouse tomatoes which are planted from February 25 to March 20. For more details on greenhouse lettuce rotations, see Growing Lettuce in Greenhouses, Reference No. 18.

Soil Preparation

Fertile sandy loam and silt loam soils, with high organic matter content, are best adapted to the production of head lettuce. All soil used for growing lettuce must be steamed prior to seeding or planting.

Temperature

The best quality lettuce is produced at night temperatures of 45° to 50°F, with a 5° rise on dull days and a 10° to 15°F rise on sunny days. Bibb lettuce may be grown at the same temperature as greenhouse tomatoes (58° to 60°F).

The sleeve, or plastic tube method of air circulation and ventilation is ideal for lettuce. It is described in greater detail on page 26.

Seeding and Transplanting

The seeds are sown in sterilized soil 7 weeks before the plants are to be planted into ground beds. Five hundred to 1,500 seeds can be sown in an ordinary sized flat, 17 x 22 inches. The seedlings are transplanted into flats of sterilized soil, spaced 1-1/2 x 1-1/2 inches, 8 or 9 days after the seeds are sown. Transplanting the seedlings while they are small prevents injury to the roots. These transplanted seedlings should be grown in the flats for about 2 to 3 weeks, at which time they should be planted in beds in the floor of the greenhouse. If allowed to remain in the flats until they are crowded, poor quality lettuce will be produced.

Planting

Lettuce is planted directly in the floor of the greenhouse in beds of different widths, depending on the width of the greenhouse and the arrangement of walk spaces. The walk spaces are usually 24 inches wide. Grand

Rapids lettuce is usually spaced at 8 by 8 inches, which gives 2,250 plants per 1000 square feet. Bibb is usually planted 7 by 7 inches which gives 2,939 plants per 1000 square feet. Each plant should be planted with as much soil as possible. They should be set shallowly enough so that a small portion of the stem is above the soil surface.

Watering

Watering of greenhouse lettuce is usually done by means of overhead pipe lines with spray nozzles spaced about 12 inches apart. The nozzles are capable of throwing water about 30 feet. By the use of a swinging joint at the valve end of the pipe, the pipe can be rotated slowly to water an entire greenhouse up to 50 feet in width.

Watering should be done thoroughly, and only as frequently as it is necessary. Lettuce is subject to a number of diseases that are favored by moist, humid conditions, so watering should be done only when the foliage can dry quickly. If watering must be done in dull weather, it is a good idea to raise the temperature a few degrees to encourage rapid drying of the leaves.

Carbon Dioxide

The addition of carbon dioxide to the greenhouse atmosphere to a level of about 1500 ppm greatly increases yields and shortens the time to harvesting of the crop.

Harvesting

Leaf lettuce is cut before it starts to develop seedstalks. If the price is good the plants may be cut when they are only 6 or 8 inches tall. However, when a good price is anticipated throughout the growing period, the plants are allowed to attain the maximum growth until they weigh as much as 1 pound.

Head lettuce is cut when the head is solid and before seedstalks start to develop. Individual heads weigh about 1 pound at maximum marketable size. A few sample heads are usually cut open and examined to determine when the crop is ready to be harvested. Pressure should never be exerted on the head when determining whether it is ready for harvesting. Pressure tears the crisp leaves, allowing fungus diseases to enter the head, making it unmarketable.

A sharp knife is used to cut lettuce at or just below the surface of the ground. Soiled and diseased leaves are removed before packing. It is not good to cut lettuce just after an irrigation because much breakage will occur when handling the brittle leaves.

Packing

Leaf lettuce is usually packed in baskets with a 10-pound capacity. It is soaked in water to keep it fresh and sent to market without being iced. Head lettuce is packed in crates which hold from 4 to 7 dozen heads. The crates are often lined with heavy waterproof paper. The heads are packed tightly in three layers with the stem ends up. Cracked ice is placed between the layers and on the top layer of each crate if shipping is done in hot weather or will require several hours.

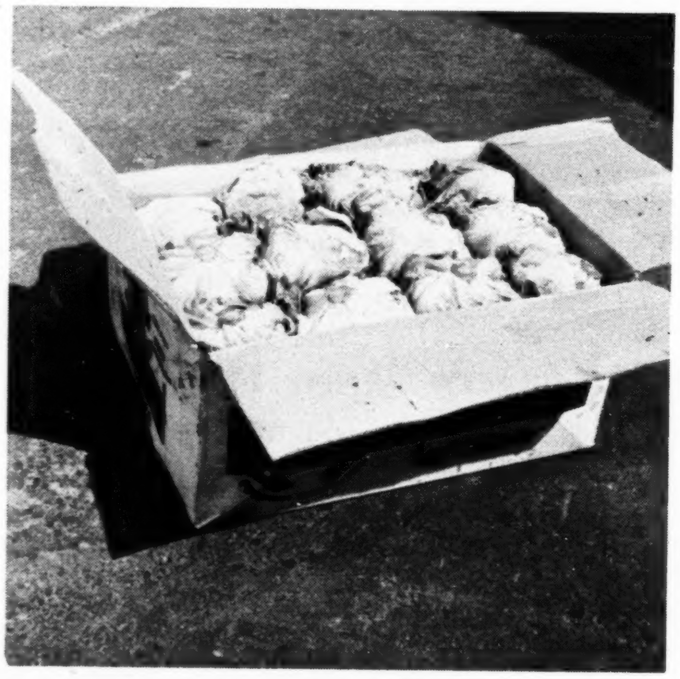


Figure 114. A crate of greenhouse-grown lettuce.

Storage

Head lettuce can be stored for a period of 3 to 4 weeks at a temperature of 32°F. This is sometimes practiced if there is a possibility of a better market price several weeks after the crop must be harvested.

Pest Control

Some fine illustrations of insects that attack lettuce may be seen in Control of Insect Pests of Greenhouse Vegetables, Reference No. 9. Another good publication is 1969 Recommended Insecticides and Miticides, Reference No. 26.

The main insects that attack lettuce and the method used to control them are:

1. Army worms - parathion, naled
2. Aphids - parathion, TEPP, dimethoate, malathion, Phosdrin

The U. S. Government has regulations governing how soon lettuce may be marketed after applying certain insecticides. The materials and time intervals are:

Material	Time
parathion	3 days
TEPP	3 days
dimethoate	7 days
malathion	7 days
Phosdrin	2 days
naled	4 days

Some of the diseases and their method of control are:

1. Bottom rot - a fungus disease common during damp weather. It enters the plant through the lower leaves that are in contact with the soil. Steam sterilization of the soil is an effective prevention
2. Lettuce drop - causes wilting and sudden collapse of the outer leaves. Steam sterilization of soil is an effective prevention
3. Mosaic - a virus disease that causes the mottling of the leaves and stunting of the plants. The disease is spread by sucking insects such as aphids. The transfer of the disease can be prevented by controlling the aphids

You may want to read about disease control for lettuce in greater detail in 1969 Fungicides and Nematicides, Reference No. 16.

SUGGESTIONS AND REFERENCES FOR THE TEACHER

References:

Control of Insect Pests of Greenhouse Vegetables. Reference No. 9.

1969 Fungicides and Nematicides. Reference No. 16.

Growing Lettuce in Greenhouses. Reference No. 18.

1969 Recommended Insecticides and Miticides. Reference No. 26.

Suggested Learning Activities

1. Demonstrate sowing seeds, transplanting, and planting greenhouse lettuce.
2. Arrange for students to visit a greenhouse that is growing a lettuce crop.

Test

1. Name the most popular lettuce cultivars.
2. What kind of weather condition is best for high quality lettuce?
3. What is the range, in weeks, from planting to harvesting a greenhouse lettuce crop?
4. Why is it important to keep lettuce foliage dry?
5. At what stage should head lettuce be harvested?
6. Contrast the packing of leaf lettuce and head lettuce for shipping.

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3. The American Florist (bimonthly), The Society of American Florists, Sheraton-Park Hotel, Washington, D. C. 20008; available to members only.
4. Florists' Review (weekly), Florists' Publishing Company, 343 South Dearborn Street, Chicago, Illinois 60604; $8.00 per year.
5. The Exchange, (weekly), Florist and Nursery Exchange, 434 South Wabash Avenue, Chicago, Illinois 60605; $8.00 per year.
6. Southern Florist and Nurseryman, 120 St. Louis Avenue, Fort Worth, Texas.

APPENDIX A

Cumulative Table of Days Per Year

Day Mo.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1.	1	32	60	91	121	152	182	213	244	274	305	335
2.	2	33	61	92	122	153	183	214	245	275	306	336
3.	3	34	62	93	123	154	184	215	246	276	307	337
4.	4	35	63	94	124	155	185	216	247	277	308	338
5.	5	36	64	95	125	156	186	217	248	278	309	339
6.	6	37	65	96	126	157	187	218	249	279	310	340
7.	7	38	66	97	127	158	188	219	250	280	311	341
8.	8	39	67	98	128	159	189	220	251	281	312	342
9.	9	40	68	99	129	160	190	221	252	282	313	343
10.	10	41	69	100	130	161	191	222	253	283	314	344
11.	11	42	70	101	131	162	192	223	254	284	315	345
12.	12	43	71	102	132	163	193	224	255	285	316	346
13.	13	44	72	103	133	164	194	225	256	286	317	347
14.	14	45	73	104	134	165	195	226	257	287	318	348
15.	15	46	74	105	135	166	196	227	258	288	319	349
16.	16	47	75	106	136	167	197	228	259	289	320	350
17.	17	48	76	107	137	168	198	229	260	290	321	351
18.	18	49	77	108	138	169	199	230	261	291	322	352
19.	19	50	78	109	139	170	200	231	262	292	323	353
20.	20	51	79	110	140	171	201	232	263	293	324	354
21.	21	52	80	111	141	172	202	233	264	294	325	355
22.	22	53	81	112	142	173	203	234	265	295	326	356
23.	23	54	82	113	143	174	204	235	266	296	327	357
24.	24	55	83	114	144	175	205	236	267	297	328	358
25.	25	56	84	115	145	176	206	237	268	298	329	359
26.	26	57	85	116	146	177	207	238	269	299	330	360
27.	27	58	86	117	147	178	208	239	270	300	331	361
28.	28	59	87	118	148	179	209	240	271	301	332	362
29.	29	...	88	119	149	180	210	241	272	302	333	363
30.	30	...	89	120	150	181	211	242	273	303	334	364
31.	31	...	90	...	151	...	212	243	...	304	335	365

FOR LEAP YEAR, ONE DAY MUST BE ADDED TO EACH NUMBER OF DAYS AFTER FEB. 28.

NOTE: To determine the number of days between two dates, subtract the smaller number from the larger.

Problem -- determine the date to start forcing an azalea cultivar for Christmas. It requires 6 weeks (42 days) forcing time.

Solution -- find 25 in the left column, and follow that line across the table to the December column. The accumulated days to December 25 are 359. Subtract 42 from 359, which gives 317. Find 317 in the table. It is the accumulated days to November 13. The date to start forcing this azalea cultivar for Christmas sale is November 13.

APPENDIX B

Flower Holidays 1970 - 1976

Year	Holidays					
	Valentine's Day	Easter Day*	Mother's Day*	Memorial Day	Thanksgiving Day*	Christmas Day
1970	Feb. 14	Mar. 29	May 10	May 30	Nov. 26	Dec. 25
1971	Feb. 14	Apr. 11	May 9	May 30	Nov. 25	Dec. 25
1972	Feb. 14	Apr. 2	May 14	May 30	Nov. 23	Dec. 25
1973	Feb. 14	Apr. 22	May 13	May 30	Nov. 22	Dec. 25
1974	Feb. 14	Apr. 14	May 12	May 30	Nov. 28	Dec. 25
1975	Feb. 14	Mar. 30	May 11	May 30	Nov. 27	Dec. 25
1976	Feb. 14	Apr. 18	May 9	May 30	Nov. 25	Dec. 25

*Variable date.

The Pennsylvania State University
College of Agriculture
Department of Agricultural Education
University Park, Pennsylvania

GREENHOUSE CROP PRODUCTION
EXAMINATION

DIRECTIONS: Do not write on this test booklet. Use the separate answer sheet. Blacken out the letter of the most appropriate answer for each question.

1. The person who is responsible for carrying out the physical work involved in producing a greenhouse crop is the:
   a. technician
   b. grower
   c. grower assistant
   d. production manager
2. Which one of the following factors is not important in determining where to locate a greenhouse:
   a. distance to major market
   b. transportation facilities available
   c. annual rainfall
   d. amount of winter sunlight
3. The size and arrangement of the greenhouse, head house and boiler rooms are most often determined by:
   a. the number of buildings to be built
   b. the type of construction used
   c. the size of the greenhouse
   d. the requirements of the crops to be grown
4. For growing potted plants, most greenhouses use the:
   a. lateral bench arrangement
   b. herringbone bench arrangement
   c. peninsular bench arrangement
   d. pivotal bench arrangement
5. The most commonly used glazing material is:
   a. glass
   b. vinyl film
   c. fiber glass
   d. plastic film
6. Coldframes are most commonly used for:
   a. cut flowers
   b. potted plants
   c. shrubs
   d. bedding plants

7. Generally, cooler temperatures cause plants to:
   a. develop and grow slower
   b. develop and grow faster
   c. flower earlier
   d. grow taller and thinner
8. The most commonly used heating system for greenhouses is:
   a. electric
   b. steam (or hot water)
   c. forced hot air
   d. natural gas
9. Ventilation is necessary in a greenhouse to:
   a. regulate temperature
   b. adjust the humidity
   c. provide air movement
   d. all of the above
10. The process during which plants manufacture sugar in the presence of sunlight is called:
    a. respiration
    b. circulation
    c. photosynthesis
    d. transpiration
11. The correct amount of water to apply is slightly more than enough to:
    a. wet the entire soil volume
    b. wet the soil at least 6 inches deep
    c. wet the soil at least 2 inches deep
    d. keep the plant from wilting for one day
12. The most important ingredient in a good soil is:
    a. silt
    b. organic matter
    c. clay
    d. sand
13. A good artificial soil mixture is made by combining:
    a. topsoil, peat, and sand or perlite
    b. topsoil and sand
    c. sand and perlite
    d. any of the above

14. The term used to refer to the number of weeks from the time short days are started until the date of flowering of chrysanthemums is:
    a. day length
    b. flowering date
    c. week group
    d. life cycle
15. Greenhouse chrysanthemum is propagated by:
    a. stem tip cuttings
    b. leaf-petiole cuttings
    c. root cuttings
    d. seeds
16. The temperature is lowered during the last 3 - 4 weeks of a chrysanthemum crop to:
    a. save on fertilizer costs
    b. cause the plant to use less water
    c. cause more intense color in the flower
    d. keep the flower from coloring
17. Potted chrysanthemums are ready to sell when:
    a. the center of the bloom is still mostly green
    b. the petals are beginning to open
    c. the petals are completely open
    d. the center of the bloom has lost most of its green color
18. One of the most important potted plants that is grown primarily for the Christmas holiday season is:
    a. chrysanthemum
    b. azalea
    c. geranium
    d. poinsettia
19. The poinsettia is propagated from:
    a. hardwood cuttings
    b. softwood cuttings
    c. seeds
    d. leaf-petiole cuttings

20. Poinsettia stock plants should be planted at once. If planting must be delayed, the stock plants should be stored in unopened cases at a minimum temperature of:
    a. 75°F
    b. 70°F
    c. 65°F
    d. 60°F

21. Poinsettia plants are photoperiodic plants that form flower buds only if the dark part of a 24-hour day is:
    a. 6 hours or longer
    b. 8 hours or longer
    c. 10 hours or longer
    d. 12 hours or longer

22. The forcing time for Easter lily, at 60°F night temperature, is:
    a. 105 days
    b. 110 days
    c. 115 days
    d. 120 days

23. Easter lily height is controlled best by:
    a. watering practices
    b. growth retardant applications
    c. temperature manipulation
    d. photoperiod manipulation

24. The majority of bedding plants are started from:
    a. stem cuttings
    b. leaf-petiole cuttings
    c. seeds
    d. root cuttings

25. During germination most bedding plant seeds require a medium temperature of:
    a. 60° to 70°F
    b. 55° to 65°F
    c. 65° to 75°F
    d. 70° to 75°F

26. The transplanting of bedding plant seedlings should be at the stage of growth when the:
    a. seed leaves appear
    b. seed leaves have expanded
    c. first pair of true leaves appear
    d. second pair of true leaves appear
27. The geranium is usually propagated from:
    a. seeds
    b. seedlings
    c. grafting
    d. rooted cuttings
28. The most troublesome pests of potted roses are:
    a. pillbugs and sauerbrauten
    b. aphids and blackspot
    c. red spider mites and powdery mildew
    d. thrips and canker
29. A recommended planting medium for the azalea is:
    a. coarse peat
    b. fine peat
    c. peat, vermiculite, and topsoil (1-1-1)
    d. peat and topsoil (1-1)
30. The sales period for the hydrangea is:
    a. Mother's Day
    b. Easter, Mother's Day
    c. Easter, Memorial Day
    d. Easter, Mother's Day, and Memorial Day
31. The African violet is propagated from:
    a. stem cuttings
    b. leaf-petiole cuttings
    c. leaf cuttings
    d. seeds
32. The temperature for propagating foliage plants should be:
    a. 60^{o} to 65^{o}F
    b. 65^{o} to 70^{o}F
    c. 70^{o} to 75^{o}F
    d. 75^{o} to 80^{o}F

33. The recommended planting depth for spring bulbs is when the:
    - a. bulb tops protrude slightly
    - b. bulb tops are 1/4-inch under surface
    - c. bulb is 1 inch from the bottom of the pot
    - d. bulb tops are 1/2-inch under surface
34. A disspray cut flower chrysanthemum is a term that refers to:
    - a. any large-flowered type with all lateral flower buds removed
    - b. any spray-type grown with all lateral flower buds removed
    - c. any spray-type with the central flower bud removed
    - d. any spray-type grown without the removal of any flower buds
35. To improve flower size and quality of chrysanthemums, the CO_2 level should be kept at:
    - a. 300 ppm
    - b. 500 ppm
    - c. 1200 ppm
    - d. 2000 ppm
36. The most popular color of carnation grown is:
    - a. red
    - b. white
    - c. light pink
    - d. yellow
37. The greenhouse carnation is propagated by:
    - a. root cuttings
    - b. seeds
    - c. terminal cuttings
    - d. leaf cuttings
38. The correct spacing of carnation plants in the bench is:
    - a. 3 by 4 inches
    - b. 2 by 3 inches
    - c. 6 by 8 inches
    - d. 12 by 15 inches
39. Carnations grow and flower best when the range of night-to-day temperatures do not exceed:
    - a. 15°F
    - b. 5°F
    - c. 20°F
    - d. 35°F

40. Carnations should be pinched the first time:
    a. 7 to 8 weeks after planting
    b. 10 to 11 weeks after planting
    c. 14 to 15 weeks after planting
    d. 3 to 4 weeks after planting

41. The most destructive pest of carnations in hot weather is:
    a. thrips
    b. white fly
    c. red spider mite
    d. aphid

42. During transplanting, snapdragons should be handled only by their:
    a. stems
    b. leaves
    c. roots
    d. buds

43. Snapdragon blooms cannot be shipped long distances because:
    a. of the weight
    b. the stem tips turn upward
    c. the flowers have a short life
    d. they must be shipped in water

44. A plant pest that twists, cripples or misshapes the leaves at the tip of the snapdragon plant is the:
    a. aphid
    b. symphylan
    c. cabbage looper
    d. thrips

45. Chlorosis in snapdragon is caused by:
    a. improper bunching and packing
    b. pinching too early
    c. poor drainage and/or too much fertilizer
    d. the effects of a gas such as ethylene

46. A cut flower propagated by seeds which are sown on sterile nutrient agar is the:
    a. rose
    b. carnation
    c. orchid
    d. snapdragon

47. Tomato seedlings are transplanted from beds to containers:
    a. after three sets of leaves appear
    b. before the true leaves appear
    c. when the true leaves appear
    d. when the true leaves are fully developed
48. The best soil for growing greenhouse tomatoes is:
    a. sandy clay loam
    b. silt loam
    c. sandy loam
    d. clay loam
49. Workers and visitors are not permitted to smoke or carry tobacco into greenhouses in which tomatoes are grown because it:
    a. is toxic to the plants
    b. increases temperature in the greenhouse
    c. may carry virus diseases
    d. hampers the flowering of the plants
50. Bolting of greenhouse lettuce is the formation of:
    a. tough leaves
    b. lower leaves
    c. split heads
    d. seedstalks

Answer Sheet for Examination on
GREENHOUSE CROP PRODUCTION

1. a [✓ b] c d
2. a b [✓ c] d
3. a b c [✓ d]
4. a b [✓ c] d
5. [✓ a] b c d
6. a b c [✓ d]
7. [✓ a] b c d
8. a [✓ b] c d
9. a b c [✓ d]
10. a b [✓ c] d
11. [✓ a] b c d
12. a b [✓ c] d
13. [✓ a] b c d
14. a b [✓ c] d
15. [✓ a] b c d
16. a b [✓ c] d
17. a b c [✓ d]
18. a b c [✓ d]
19. a [✓ b] c d
20. a b c [✓ d]
21. a b c [✓ d]
22. a b [✓ c] d
23. a b c [✓ d]
24. a b [✓ c] d
25. a b [✓ c] d
26. a b [✓ c] d
27. a b c [✓ d]
28. a b [✓ c] d
29. [✓ a] b c d
30. a [✓ b] c d
31. a [✓ b] c d
32. a b c [✓ d]
33. [✓ a] b c d
34. a b [✓ c] d
35. a b [✓ c] d
36. a [✓ b] c d
37. a b [✓ c] d
38. a b [✓ c] d
39. [✓ a] b c d
40. a b c [✓ d]
41. a b [✓ c] d
42. a [✓ b] c d
43. a [✓ b] c d
44. [✓ a] b c d
45. a b [✓ c] d
46. a b [✓ c] d
47. a b [✓ c] d
48. [✓ a] b c d
49. a b [✓ c] d
50. a b c [✓ d]